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ABSTRACT

This color-coded competency-based teacher guide contains three units: (1) oxyacetylene welding; (2) oxyacetylene cutting; and (3) oxyacetylene braze welding and surfacing. Each unit includes the following: objective sheet--unit and specific objectives; suggested activities/instructional plan--preparation, delivery and application, evaluation, teaching suggestions, resources used in developing this unit, suggested supplemental resources, suggested activities, and instructions for evaluating student performance; answers to written test; written test; unit evaluation form; teacher supplement; transparency masters; information sheets; and job sheets. The following general information is provided: use of this publication; competency profile; instructional/task analysis; related academic and workplace skills list; and tools, equipment, and materials lists. (NLA)

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Oxyacetylene Welding & Cutting

Second Edition

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Braze Welding ·
Bronze Surfacing ·
Hardfacing ·

Teacher Edition

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Oxyacetylene Welding and Cutting
Second Edition

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Oxyacetylene Welding and Cutting
Second Edition

Teacher Edition

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Foreword

Oxyacetylene Welding and Cutting, Second Edition is part of a series of competency-based instructional materials on welding developed by the Mid-America Vocational Curriculum Consortium.

Oxyacetylene cutting, welding, and braze welding are skills required of a combination welder. Oxyacetylene skills are not demanded for all welding jobs, but knowing how to handle fuel gases safely and properly is a required skill everywhere. In *Oxyacetylene Welding and Cutting, Second Edition* students will learn to recognize the elements of a good weld puddle and gain valuable experience in improving eye/hand coordination by manipulating a torch and filler rod.

These instructional materials are designed not only for student use, but to assist teachers in improving instruction. Every effort has been made to make these materials basic, readable, and by all means useable. Teachers will need to develop instructional strategies to localize, personalize, and supplement the instructional materials to meet their individual community and student needs.

Special attention should be given to the teacher suggestions in each unit of instruction. Not only do these suggestions present strategies for providing a wide variety of teaching and motivational techniques, but present ways to increase reinforcement of academic and workplace basic skills. By reinforcing the workplace basic skills, the teacher assists students in improving their employability skills.

As you use these instructional materials, we hope you will find they contribute to the quality of your program. If any problems occur or if you have suggestions for improvement, please call us at 800-654-3988 or write us at MAVCC, 1500 West Seventh Avenue, Stillwater, OK 74074-4364.

Larry Nelson, Chairman
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Mid-America Vocational
Curriculum Consortium

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Acknowledgements

Appreciation is extended to those individuals who assisted with the review of the original *Oxyacetylene Welding and Cutting*, and contributed significantly to the development of *Second Edition*.

The contents of this publication were planned and reviewed by the following members of the Mid-America Vocational Curriculum Consortium *Oxyacetylene Welding and Cutting, Second Edition* committee:

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We once again extend thanks to the members of the committee whose fine efforts helped produce the original *Oxyacetylene Welding and Cutting*. Additional thanks go to the manufacturers and suppliers whose procedures and graphic materials have enhanced this second edition. A special thank you to the American Welding Society for their materials and assistance.

And finally to the Oklahoma Department of Vocational and Technical Education, a thank you to personnel in word processing, art, and the print shop for their help in developing and printing a fine test.

Use of Introductory Materials

Introductory materials are included in the teacher guide only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.
2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.
3. **Instructional/task analysis**—Provides a quick review of contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.
4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced. Skill areas reflected by skill groups, sub skills, and descriptions have been identified using *Workplace Basics: The Skills Employers Want*, developed by the American Society for Training and Development (ASTD) and the U.S. Department of Labor and adapted by MAVCC.
5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.
6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

A glossary of terms may also be provided in the introductory materials depending on subject matter and committee recommendations.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Oxyacetylene Welding and Cutting, Second Edition contains 3 units of instruction. Each instructional unit in a teacher guide includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher guide. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher guide only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher guide only, but may be duplicated.

Use of This Publication

Teacher supplements (Color code: White)

This component is included only in the teacher guide. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher guide only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student manual. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher guide.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student manuals contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

Academic and Workplace Skills (Classifications and Definitions)

Skill Groups	Sub Skills	Definitions
Learning Skills	Learning to learn	Developing ability to apply knowledge to other situations; knowing how to learn.
Foundation Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Math	Applying computation skills such as reasoning, estimation, and problem solving as they are actually used on the job.
	Science	Applying knowledge learned through study or practice that is based on scientific principles as they relate to specific tasks.
Communication Skills	Listening	Listening for content, conversation, long-term contexts, emotional meaning, and directions.
	Oral communication	Communicating a thought, idea, or fact in spoken form in a clear, concise manner.
Adaptability Skills	Creative thinking	Using imagination to create something new—i.e. an idea, invention, work of art.
	Problem solving (critical thinking)	Recognizing and defining problems, inventing, and implementing solutions, and tracking and evaluating results.
Personal Management Skills	Self-esteem	Developing self-confidence and creating a positive self-image.
	Motivation/goal setting	Setting and meeting defined goals and objectives.
	Personal and career development	Emphasizing self-direction by establishing and implementing a plan.
Group Effectiveness Skills	Interpersonal relations	Developing ability to maintain positive relations with others.
	Negotiation	Resolving conflict between two or more individuals.
	Teamwork	Working together in a group to reach a common goal.
Influence Skills	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Leadership	Directing/influencing group in performance of a specific task; accepting responsibility for others.

Oxyacetylene Welding and Cutting, Second Edition

Competency Profile

Name: ____________________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focused on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale:
4 - Skilled - Can perform job with no additional training.
3 - Moderately Skilled - Has performed job during training program; limited additional training may be required.
2 - Limited Skill - Has performed job during training program; additional training is required to develop skill.
1 - Unskilled - Is familiar with process, but is unable to perform job.
0 - No Exposure - No information or practice provided during training program, complete training required.
NA - Non-applicable.

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

Unit 1: Oxyacetylene Welding

_______ 1. Light, adjust, and shut down an oxyacetylene welding torch in adherence with safety standards.
_______ 2. Lay beads on flat plate with no filler rod.
_______ 3. Lay beads on flat plate with filler rod.
_______ 4. Weld an outside corner joint in the flat position.
_______ 5. Weld a butt joint in the flat position.
_______ 6. Weld a lap joint in the flat position.
_______ 7. Weld a T-joint in the flat position.
_______ 8. Weld an outside corner joint in the horizontal position.
_______ 9. Weld a butt joint in the horizontal position.
_______10. Weld a lap joint in the horizontal position.
_______11. Weld a T-joint in the horizontal position.
_______12. Weld a corner joint in the vertical position
_______13. Weld a butt joint in the vertical position
_______14. Weld a lap joint in the vertical position
_______15. Weld a T-joint in the vertical position
_______16. Weld an edge joint in the overhead position.
_______17. Weld a butt joint in the overhead position.
_______18. Weld a lap joint in the overhead position.
_______19. Weld a T-joint in the overhead position.
_______20. ____

______Written Test Score

Unit 2: Oxyacetylene Cutting

______1. Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment.
______2. Make 90° cuts and restart a cut on mild steel.
______3. Make a flame beveled cut on mild steel plate.
______4. Cut holes in mild steel.
______5. Lay out a pattern on mild steel plate and cut the pattern to specifications.
______6. Cut a pipe bevel by hand.
______7. Set up and cut a 30° bevel with a track-type torch.
______8. ______________________________

______Written Test Score

Unit 3: Oxyacetylene Braze Welding and Surfacing

______1. Weld a stringer bead with a bronze rod on steel plate.
______2. Braze weld a square groove butt joint in the flat position.
______3. Braze weld a lap joint in the horizontal position.
______4. Repair a worn tool with hardfacing.
______5. ______________________________

______Written Test Score

COMMENTS: ______________________________

____

____

____

____

Evaluator: ______________________ Date: ______________

*** Permission to duplicate this profile is granted.**

Oxyacetylene Welding and Cutting, Second

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 1: Oxyacetylene Welding

1. Terms and definitions
2. Benefits of learning oxyacetylene welding and cutting
3. Equipment needed for oxyacetylene welding
4. Safety rules for the oxyacetylene workplace
5. Personal safety requirements
6. Eye protection required for oxyacetylene welding
7. Pressure regulating valves
8. Welding hoses and their characteristics
9. Parts of a welding torch
10. Types of mixers
11. Welding tips and their uses
12. Safety rules for oxyacetylene cylinders and gases
13. Oxyacetylene flames and their characteristics
14. Guidelines for flame adjustment
15. Backfire and flashback
16. Welding tip selection
17. Filler rod selection, handling, and safety

Related Information: What the Student Should Know

18. AWS designations for iron and steel gas welding rods
19. Flux selection, handling, and safety
20. Welding positions
21. Welding joints and positions
22. Basic types of welds and their AWS symbols
23. Elements of good fusion welding
24. Rules of thumb for rod and torch angles
25. The forehand technique in fusion welding
26. The backhand technique in fusion welding
27. How to control rod and flame motion
28. Preheating, interpass, and postheating
29. Cleanup, inspection, and testing
30. Steps in setting up cylinders and regulators
31. Steps in purging oxygen and fuel gas regulators
32. Final steps in setting up oxy-fuel equipment

Application: What the Student Should Be Able to Do

33. Light, adjust, and shut down an oxyacetylene welding torch in adherence with safety standards. (Job Sheet 1)
34. Lay beads on flat plate with no filler rod. (Job Sheet 2)
35. Lay beads on flat plate with filler rod. (Job Sheet 3)
36. Weld an outside corner joint in the flat position. (Job Sheet 4)
37. Weld a butt joint in the flat position. (Job Sheet 5)
38. Weld a lap joint in the flat position. (Job Sheet 6)
39. Weld a T-joint in the flat position. (Job Sheet 7)
40. Weld an outside corner joint in the horizontal position. (Job Sheet 8)
41. Weld a butt joint in the horizontal position. (Job Sheet 9)
42. Weld a lap joint in the horizontal position. (Job Sheet 10)
43. Weld a T-joint in the horizontal position. (Job Sheet 11)
44. Weld a corner joint in the vertical position. (Job Sheet 12)
45. Weld a butt joint in the vertical position. (Job Sheet 13)
46. Weld a lap joint in the vertical position. (Job Sheet 14)
47. Weld a T-joint in the vertical position. (Job Sheet 15)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
	48. Weld an edge joint in the overhead position. (Job Sheet 16)
	49. Weld a butt joint in the overhead position. (Job Sheet 17)
	50. Weld a lap joint in the overhead position. (Job Sheet 18)
	51. Weld a T-joint in the overhead position. (Job Sheet 19)
Unit 2: Oxyacetylene Cutting	
1. Terms and definitions	
2. Advantages of oxyacetylene cutting	
3. Parts of an oxyacetylene cutting torch	
4. Cutting tip design	
5. Cutting tip selection	
6. Cleaning cutting tips	
7. Tip cleaning tools and their uses	
8. Rules for tip use	
9. Metal preparation for oxyacetylene cutting	
10. Steps in starting a cut	
11. Techniques for restarting a cut	
12. Techniques for cutting straight lines	
13. Solutions for controlling kerf	
14. Elements of a good cut	
15. Reasons for poor cuts	
16. Safety requirements for oxyacetylene cutting	

Related Information: What the Student Should Know

17. Manifold systems
18. Track-type cutting machines
19. Shape cutting machines
20. Pipe beveling machines
21. Automated cutting machines
22. Eye protection required for oxyacetylene cutting

Application: What the Student Should Be Able to Do

24. Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment. (Job Sheet 1)
25. Make 90° cuts and restart a cut on mild steel. (Job Sheet 2)
26. Make a flame beveled cut on mild steel plate. (Job Sheet 3)
27. Cut holes in mild steel. (Job Sheet 4)
28. Lay out a pattern on mild steel plate and cut pattern to specifications. (Job Sheet 5)
29. Cut a pipe bevel by hand. (Job Sheet 6)
30. Set up and cut a 30° bevel with a track-type torch. (Job Sheet 7)

Unit 3: Oxyacetylene Braze Welding and Surfacing

1. Terms and definitions
2. Difference between fusion welding and braze welding
3. Difference between brazing and braze welding
4. Advantages of braze welding
5. Limitation of braze welding
6. The importance of precoating in braze welding
7. The purposes of flux
8. Characteristics of filler rods for braze welding
9. Factors in successful braze welding
10. Joint preparation for braze welding

Related Information: What the Student Should Know

11. Ways to remove oxides in joint preparation for braze welding
12. Techniques for braze welding steel and cast iron
13. Braze welding problems and their causes
14. Rebuilding and resurfacing processes
15. Advantages of bronze surfacing
16. Limitations of bronze surfacing
17. Ways to prepare for bronze surfacing
18. Techniques for bronze surfacing
19. The uses of hardfacing
20. Hardfacing alloys and their characteristics
21. Hardfacing powders
22. Advantages of hardfacing with an acetylene torch
23. Ways to prepare for hardfacing
24. Preheating and cooling requirements for hardfacing
25. Techniques for oxyacetylene hardfacing
26. Techniques for making a second pass when oxyacetylene hardfacing
27. Safety precautions for hardfacing

Application: What the Student Should Be Able to Do

28. Weld a stringer bead with a bronze rod on steel plate. (Job Sheet 1)
29. Braze weld a square groove butt joint in the flat position. (Job Sheet 2)
30. Braze weld a lap joint in the horizontal position. (Job Sheet 3)
31. Repair a worn tool with hardfacing. (Job Sheet 4)

Related Academic and Workplace Skills
For (*Oxyacetylene Welding and Cutting, Second Edition*)

Task	Skill Group	Sub Skill	Description
Unit 1: Oxyacetylene Welding			
Light, adjust, and shut down an oxyacetylene welding torch in adherence with safety standards. (J.S. 1)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to the operation of a welding torch
Lay beads on flat plate with no filler rod. (J.S. 2)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to the manipulation of a torch to weld with no filler rod
Lay beads on flat plate with filler rod. (J.S. 3)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to the manipulation of a torch to weld with filler rod
Weld an outside corner joint in the flat position. (J.S. 4)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld an outside corner joint in the flat position
Weld a butt joint in the flat position. (J.S. 5)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a butt joint in the flat position
Weld a lap joint in the flat position. (J.S. 6)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a lap joint in the flat position
Weld a T-joint in the flat position. (J.S. 7)	Foundation skills	Reading	Comprehends written instructions and follows a procedure

Task	Skill Group	Sub Skill	Description
		Science	Applies technology training to weld a T-joint in the flat position
Weld an outside corner joint in the horizontal position. (J.S. 8)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld an outside corner joint in the horizontal position
Weld a butt joint in the horizontal position. (J.S. 9)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a butt joint in the horizontal position
Weld a lap joint in the horizontal position. (J.S. 10)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a lap joint in the horizontal position
Weld a T-joint in the horizontal position. (J.S. 11)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a T-joint in the horizontal position
Weld a corner joint in the vertical position. (J.S. 12)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a corner joint in the horizontal position
Weld a butt joint in the vertical position. (J.S. 13)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a butt joint in the vertical position
Weld a lap joint in the vertical position. (J.S. 14)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a lap joint in the vertical position

Task	Skill Group	Sub Skill	Description
Weld a T-joint in the vertical position. (J.S. 15)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a T-joint in the vertical position
Weld an edge joint in the overhead position. (J.S. 16)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld an edge joint in the overhead position
Weld a butt joint in the overhead position. (J.S. 17)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a butt joint in the overhead position
Weld a lap joint in the overhead position. (J.S. 18)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a lap joint in the overhead position
Weld a T-joint in the overhead position. (J.S. 19)	Foundation skills	Reading	Comprehends written instructions and follows a procedure
		Science	Applies technology training to weld a T-joint in the overhead position
Unit 2: Oxyacetylene Cutting			
Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment. (J.S. 1)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to operation of a cutting torch
Make 90° cuts and restart a cut on mild steel. (J.S. 2)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to a cutting procedure
Make a flame-beveled cut on mild steel plate. (J.S. 3)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to a beveling procedure

Task	Skill Group	Sub Skill	Description
Cut holes in mild steel. (J.S. 4)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to a cutting procedure
Lay out a pattern on mild steel plate and cut the pattern to specifications. (J.S. 5)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to a lay out and cutting procedure
Cut a pipe bevel by hand. (J.S. 6)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Math	Measures and marks the circumference of a pipe
		Science	Applies technology training to a lay out and beveling procedure
Set up and cut a 30° bevel with a track-type torch. (J.S. 7)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Math	Selects and adjust proper torch angle
		Science	Applies technology training to operate a machine for a beveling procedure

Unit 3: Oxyacetylene Braze Welding and Surfacing

Weld a stringer bead with a bronze rod on steel plate. (J.S. 1)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to a brazing process
Braze weld a square groove butt joint in the flat position. (J.S. 2)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to braze weld a square groove butt joint in the flat position
Braze weld a lap joint in the horizontal position. (J.S. 3)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to braze weld a lap joint in the horizontal position
Repair a worn tool with hardfacing. (J.S. 4)	Foundation skills	Reading	Comprehends written information and applies it to a task
		Science	Applies technology training to a hardfacing procedure

Oxyacetylene Welding and Cutting, Second Edition

Tools, Equipment, and Materials List

Acetylene cylinders
Ball peen hammer
Center punch
Chains or cylinder supports
Chipping hammer
Cutting table with grated surface and slag box
Cutting torch body
Cylinder wrench
Face shield
Filler rods for braze welding
Filler rods for hardfacing
Fire-brick work table
Flux
Fuel gas cylinders (optional)
Gas welding rods
Hand-guided, tractor-type, or shape-cutting machines
Hard surfacing powders (optional)
Leak detector
Mild steel plate, cast iron, and pipe as specified
Oxygen cylinders
Pipe beveling machine
Pliers
Portable grinder/sander
Pressure regulators for oxygen and acetylene
Protective clothing as specified
Safety glasses
Selected brazing tips
Selected cutting torch tips
Selected welding torch tips
Soapstone
Sparklighter
Temperature-indicating crayons or pellets
Tip cleaner
Tip drill
Tip nip
Torch wrench
Vise
Welding and cutting goggles
Welding hoses with reverse-flow check valves
Welding torch body
Wire brush

References

Basic Oxy-Acetylene Welding, Cutting, and Heating Practices. New York: Union Carbide corporation, Linde Division, 1979.

Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.

Fortney, Clarence and Mike Gregory. *Oxyacetylene Welding and Cutting.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

Safety Meeting (a brochure to promote the safe handling of oxy-fuel gas equipment.) Watertown, SD: Smith Equipment Division, Tescom Corporation, 1985.

Standards Symbols for Welding, Brazing, and Nondestructive Examination (ANSI/AWS A2.4-86). Miami, FL: American Welding Society, 1986.

Standard Welding Terms and Definitions (ANSI/AWS A3.0-89). Miami, FL: American Welding Society, 1989.

Victor Apparatus and Equipment Master Catalog. Denton, TX: Victor Equipment Company, 1988.

Oxyacetylene Welding
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to safely light, adjust, and shut down an oxyacetylene system, run beads on flat plate with and without filler metal, and weld butt joints, lap joints, T-joints, corner joints, and edge joints in all positions. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to oxyacetylene welding with their correct definitions.
2. Select true statements about benefits of learning oxyacetylene welding and cutting.
3. Complete a list of equipment needed for oxyacetylene welding.
4. Complete statements about safety rules for the oxyacetylene workplace.
5. Select solutions for personal safety requirements.
6. Complete statements about eye protection required for oxyacetylene welding.
7. Solve problems about pressure regulating valves.
8. Differentiate between welding hoses and their characteristics.
9. Complete statements about parts of a welding torch.
10. Solve problems about types of mixers and their purposes.
11. Select true statements about welding tips and their uses.
12. Solve problems about basic safety rules for oxyacetylene cylinders and gases.
13. Complete a chart of oxyacetylene flame characteristics and uses.

Objective Sheet

14. Select true statements about guidelines for flame adjustment.

15. Complete statements about characteristics and causes of backfire and flashback.

16. Complete statements about welding tip selection.

17. Complete statements about filler rod selection, handling, and safety.

18. Select true statements about AWS designations for iron and steel gas welding rods.

19. Select true statements about flux selection, handling, and safety.

20. Identify welding positions.

21. Identify basic types of welds and their AWS symbols.

22. Identify basic welding joints and positions.

23. Solve problems about elements of good fusion welding.

24. Select true statements about rules of thumb for rod and torch angles.

25. Select true statements about guidelines for using the forehand technique in fusion welding.

26. Select true statements about guidelines for using the backhand technique in fusion welding.

27. Complete statements about techniques for controlling flame and rod motion.

28. Select true statements about guidelines for preheating, interpass, and postheating.

29. Select correct procedures for cleanup, inspection, and testing.

30. Arrange in order the steps in setting up cylinders and regulators.

31. Select true statements about steps in purging oxygen and fuel gas regulators.

32. Select correct procedures for final steps in setting up oxy-fuel equipment.

33. Light, adjust, and shut down an oxyacetylene welding torch in compliance with safety standards. (Job Sheet 1)

34. Lay beads on flat plate with no filler rod. (Job Sheet 2)

Objective Sheet

35. Lay beads on flat plate with filler rod. (Job Sheet 3)

36. Weld an outside corner joint in the flat position. (Job Sheet 4)

37. Weld a square-groove butt joint in the flat position. (Job Sheet 5)

38. Weld a lap joint in the flat position. (Job Sheet 6)

39. Weld a T-joint in the flat position. (Job Sheet 7)

40. Weld an outside corner joint in the horizontal position. (Job Sheet 8)

41. Weld a square-groove butt joint in the horizontal position. (Job Sheet 9)

42. Weld a lap joint in the horizontal position. (Job Sheet 10)

43. Weld a T-joint in the horizontal position. (Job Sheet 11)

44. Weld a corner joint in the vertical position. (Job Sheet 12)

45. Weld a square-groove butt joint in the vertical position. (Job Sheet 13)

46. Weld a lap joint in the vertical position. (Job Sheet 14)

47. Weld a T-joint in the vertical position. (Job Sheet 15)

48. Weld an edge joint in the overhead position. (Job Sheet 16)

49. Weld a square-groove butt joint in the overhead position. (Job Sheet 17)

50. Weld a lap joint in the overhead position. (Job Sheet 18)

51. Weld a T-joint in the overhead position. (Job Sheet 19)

Oxyacetylene Welding
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Oxyacetylene Tank and Torch Assembly (Objective 3)
   TM 2—Oxyacetylene Fusion Welding Flames (Objectives 13 and 14)
   TM 3—Welding Tip Data (Objective 16)
   TM 4—Gas Welding Rod Data (Objective 17)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheets. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

Suggested Activities

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. When demonstrating the job sheets, impress upon students the need to do things in order: properly and safely setting up equipment, properly preparing joints, working with a neutral flame, and using tack welds. (**Science**, applying scientific principles as they relate to specific tasks.)

2. Use the job sheets to promote the concept of "dexterity" and good eye-hand coordination required for manipulation of the torch, the welding rod, and the weld puddle. Alert students to the value of eye-hand coordination in other arc welding processes such as GTAW and GMAW. (**Learning to learn**, applying procedures to new situations.)

3. Emphasize the importance of visually inspecting welds, and impress students that major parts of welding include preparation of the joint before the weld starts and inspection of the weld after welding has ended. (**Math**, applies reasoning and problem solving as they are used on the job.)

4. Demonstrate the shutdown procedure used in the event of backfire or flashback. Different manufacturers may recommend shutting off either the fuel or oxygen first in the event of flashback, but abide by the guideline from the American Welding Society: the most important concern is to get both valves closed quickly.

5. Stress safety at all time and demand that students wear safety glasses in the welding facility.

6. Show available videotapes of films about oxyacetylene welding and cutting safety. Some are listed in the supplemental resources included in these suggested activities.

Suggested Activities

Resources Used in Developing This Unit

1. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.

2. O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

3. *Standard Welding Terms and Definitions (ANSI/AWS A3.0-89).* Miami, FL: American Welding Society, 1989.

4. *Standards Symbols for Welding, Brazing, and Nondestructive Examination (ANSI/AWS A2.4-86).* Miami, FL: American Welding Society, 1986.

5. *Victor Apparatus and Equipment Master Catalog.* Denton, TX: Victor Equipment Company, 1988.

6. *Basic Oxy-Acetylene Welding, Cutting, and Heating Practices.* New York: Union Carbide Corporation, Linde Division, 1979.

7. *Safety Meeting.* (A brochure to promote the safe handling of oxy-fuel gas equipment.) Watertown, SD: Smith Equipment Division, Tescom Corporation, 1985.

Suggested Supplemental Resources

1. CGA-1 "Safe Handling and Storage of Compressed Gases." Slide/audio cassette or ½" VHS videotape. Available from:

   Compressed Gas Association
   1235 Jefferson Davis Highway
   Arlington, VA 22202
   703-979-0900

2. DCA-2 "Oxyacetylene Welding." Covering safety, setup, fillet and groove welds with various joints, braze welding, and silver brazing. 12 filmstrips or 12 videocassettes covering four units of instruction. Available from:

   DCA Educational Products
   Kellers Church Road
   P.O. Box 338
   Bedminister, PA 18910
   1-800-345-3548 or
   215-795-2841

Suggested Activities

3. FIL-2 "Oxyacetylene Welding & Cutting: Braze Welding." Covering lighting and adjusting flame and correct techniques for sheet, plate, and castings. 16mm film and ½" VHS videotape. Available from:

   Films, Inc.
   5544 North Ravenswood Avenue
   Chicago, IL 60640
   1-800-323-4222 ext. 43 or
   312-878-2600 ext. 43

4. GLA-5 "Weld in Safety." Covers safely handling cylinders, setting up and closing equipment, and preventing flashbacks. 16mm film, also videocassette. Available from:

   Greater Los Angles Chapter
   National Safety Council
   The Film Library
   3450 Welshire Boulevard, Suite 90010
   Los Angles, CA 90010
   1-800-421-9598 or
   213-384-8114 (in California)

5. HOB-30 "Oxyacetylene Welding, Cutting, Brazing." Covers safety, basics, and many applications (with instructor's guide). 16mm film and ½" VHS videotape. Available from:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   513-332-5217

6. KEN-2 "Gas Welding & Cutting Training Program." Covers safety, basics, and applications of welding and cutting, complete with welding and cutting kit and other materials. 16mm film or videotape available in both English and Spanish. Available from:

   Ken Cook Education Systems
   12856 West Silver Spring Drive
   P.O. Box 207
   Butler, WI 53007
   1-800-362-2665

Suggested Activities

7. VIC-2 "Oxy-Fuel Safety, It's Up To You." Covers equipment care, hazards of reverse flow and flashback. 16mm film or ½" VHS videotape. Available from:

   Victor Equipment Company
   Film Communications
   10466 Plano Road
   Dallas, TX 75238
   214-340-2579

8. VTR-1 "Oxyfuel Welding." Consists of 14 videotapes with workbook/videotext. Videotapes. Available from:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   1-800-828-2889 or
   612-944-8190

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher guide or student manual. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Oxyacetylene Welding
Unit 1

Answers to Written Test

1. a. 3
   b. 5
   c. 7
   d. 9
   e. 8
   f. 10
   g. 1
   h. 6
   i. 2
   j. 4

2. a, b, c, d, e, f

3. c. Regulator
   d. Regulator
   e. Encased together
   f. Assorted tips
   g. Safety glasses
   i. Check
   k. Wire brush

4. a. Fly for several feet
   b. But do not
   c. Hot metal
   d. Welding or cutting
   e. Acetylene, acetylene

5. a. Taping the pocket openings shut
   b. Putting on a proper welding cap
   c. Changing to a pair of shoes with high tops
   d. Absolutely wrong

6. a. Safety glasses
   b. Safety glasses
   c. Radiation burns
   d. A good view of the work zone

7. a. 1
   b. 2

8. a. Red
   b. Green, black
   c. A V-groove and left-handed threads
   d. A plain surface and right-handed threads

9. a. Held; needle
   b. Throat

Answers to Written Test

10. a. 2
b. 1

11. b, c, d

12. a. 2
b. 1
c. 2
d. 1
e. 1

13. a. 4
b. 2
c. 1
d. 3

14. a, c, e

15. a. Backing; pop
b. Burning back; hiss or squeal
c. Too close to
d. Incorrect
e. Purge

16. a. Metal to be welded
b. Wear
c. Size tip
d. Carefully followed
e. Operator's skill
f. 25, 25

17. a. Same or similar
b. For the thickness of the metal being welded
c. Properly labeled
d. Combustible
e. Bend

18. a

19. a, c

20. a. 2
b. 4
c. 3
d. 1

Answers to Written Test

21. a. 3
    b. 1
    c. 2
    d. 4

22. a. T-joint, 3F, 4F, 1F, 2F
    b. Butt joint, 4G, 1G, 2G, 3G
    c. Lap joint, 1F, 2F, 3F, 4F
    d. Edge joint, 2G, 3G, 4G, 1G
    e. Corner joint, 3F, 4F, 1F, 2F

23. a. 2
    b. 4
    c. 1
    d. 5

24. a, b, d, e

25. a, b

26. a, b

27. a. Back and forth
    b. Opposite
    c. Outer
    d. Adds, takes away

28. a, c

29. a. 3
    b. 2
    c. 2

30. a. 7
    b. 4
    c. 2
    d. 5
    e. 6
    f. 1
    g. 3

31. a, c

32. a. 2
    b. 3
    c. 1

Oxyacetylene Welding
Unit 1

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

______a. Metal to be welded, brazed, or cut

______b. A welding process that joins metals by heating them to a melting point and allowing them to fuse or flow together

______c. A wire used for correct spacing of butt joints

______d. Application of heat to a base metal during a welding process

______e. Distance from the original surface of the base metal to that depth at which fusion stops

______f. Heating after a welding operation to provide uniform cooling and stress relief

______g. Heating prior to a welding or cutting operation

______h. A process whereby base metals are heated to even temperature below the critical range, held at that temperature for a given time, and uniformly cooled to avoid distortion, cracking, or other stress-related problems

______i. A short weld used to temporarily hold workpieces in place

______j. A numbered reference to the physical positioning of a workpiece with 1 as flat, 2 as horizontal, 3 as vertical, and 4 as overhead

1. Preheating
2. Tack weld
3. Base metal
4. Welding positions
5. Fusion welding
6. Stress relief
7. Gap wire
8. Penetration
9. Interpass heating
10. Postheating

Written Test

2. Select true statements about benefits of learning oxyacetylene welding and cutting. Place an "X" beside each true statement.

______a. Teaches methods used in forming, recognizing, and controlling a weld puddle

______b. Teaches methods of properly holding and manipulating welding equipment and develops techniques that are useful in other welding processes

______c. Provides practice leading to good eye-hand coordination required in the welding trade

______d. Teaches the basics of metallurgy and the characteristics of metals being welded or cut

______e. Provides a familiarity with the welding workplace and its activities

______f. Teaches a welding skill that will increase employability when facing job demands that require both arc and oxyacetylene skills

3. Complete a list of equipment required for oxyacetylene welding. Circle the information that best completes individual items.

a. Oxygen cylinder

b. Acetylene cylinder

c. Pressure (valve) (regulator) for oxygen

d. Pressure (valve) (regulator) for acetylene

e. Two hoses (encased together) (separated for easy identification)

f. Welding torch with (assorted tips) (basic welding elbow)

g. Welding goggles and (safety glasses) (face shield)

h. Sparklighter

i. (Pressure) (Check) valves to prevent flashback

j. Cylinder wrench

k. Chipping hammer and (grinder) (wire brush)

Written Test

4. Complete statements about safety rules for the oxyacetylene workplace. Circle the information that best completes each statement.

   a. Keep work area free of grease, oil, and flammable materials because flying sparks can (fly for several feet) (explode) and cause a fire.

   b. Cool or quench hot metal and extinguish all sparks before leaving the work area, (and always) (but do not) quench during a welding process.

   c. Do not leave torches, tips, or (hot metal) (hoses) where they can be accidentally touched by a co-worker or visitor.

   d. Never carry matches or lighters filled with butane or propane into any work area where any kind of (welding) (welding or cutting) is taking place.

   e. Do not withdraw too much volume at one time from an (oxygen) (acetylene) tank because a high demand of (oxygen) (acetylene) could withdraw acetone form the cylinder and create a hazardous condition.

5. Select solutions for personal safety requirements. Circle the number of the item that provides the best solution to each of the following.

   a. A co-worker is working in a shirt that has pockets that do not have pocket flaps. The problem can quickly be solved by:

      (1) Stopping and changing shirts
      (2) Taping the pocket openings shut
      (3) Putting the job off until later

   b. A lady welder is working while wearing a plastic cap. The problem can be solved by:

      (1) Using a welding helmet
      (2) Wrapping a damp towel around her hair
      (3) Putting on a proper welding cap

   c. A co-worker is wearing a pair of low-cut sneakers while welding. The problem can be solved by:

      (1) Changing to a pair of shoes with high tops
      (2) Changing positions so the feet will be clear of the welding area
      (3) There is no problem because he is welding, not cutting

   d. A co-worker says that wearing safety glasses under goggles is not really needed. The co-worker is:

      (1) Probably right
      (2) Probably wrong
      (3) Absolutely wrong

6. Complete statements about eye protection required for oxyacetylene welding. Circle the information that best completes each statement.

   a. Wear (safety glasses) (a face shield) when cleaning or chipping base metals.

   b. Wear (safety glasses) (welding goggles) and a face shield when grinding joints or bevels.

   c. Wear welding goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from (radiation burns) (sparks).

   d. Play it safe and start with a lens shade too dark to see the work zone, then work down to a lighter shade that affords (a good view of the work zone) (protection) without straining your eyes.

7. Solve problems about pressure regulating valves. Circle the best solution to each of the following.

   a. A co-worker needs to know where to find the oxygen cylinder pressure. You should advise the co-worker to:

      (1) Check the regulator gauges because one shows working pressure for the torch and the other shows cylinder pressure.
      (2) Turn the adjusting screw until the working pressure begins to register.
      (3) Look at the working pressure gauge because it should be the same as the cylinder pressure.

   b. You notice that a co-worker is using an acetylene pressure that is too high. You should advise the co-worker to:

      (1) Adjust the acetylene on the torch needle valve.
      (2) Turn the acetylene adjusting screw counterclockwise to decrease pressure.
      (3) Quit welding until the pressure automatically adjusts itself.

8. Differentiate between welding hoses and their characteristics. Circle the appropriate answers to each of the following.

   a. Acetylene hoses are always (red) (black) (green).

   b. Oxygen hoses are usually (green) (red), but sometimes (black) (yellow).

   c. Acetylene connectors have (a V-groove and left-handed threads) (a plain surface and right-handed threads).

   d. Oxygen connectors have (a V-groove and left-handed threads) (a plain surface and right-handed threads).

Written Test

9. Complete statements about parts of a welding torch. Circle the information that best completes each statement.

   a. The torch body is that part of a torch designed to be (held) (adjusted); it contains two (control) (needle) valves to control the flow of acetylene and oxygen.

   b. The welding head is the torch component that contains a mixer or injector, the mixing (throat) (chamber), and the welding tip to control the flame.

10. Solve problems about types of mixers and their purposes. Circle the number of the best solution to each of the following situations.

    a. The planning for a welding project calls for the most effecient use of oxygen and fuel gases for oxyacetylene welding applications. This means the project requires:

       (1) A good injector type mixer
       (2) An equal-pressure type mixer

    b. A project that requires oxygen be supplied at high pressure requires:

       (1) A good injector type mixer
       (2) An equal-pressure type mixer

11. Select true statements about welding tips and their uses. Place an "X" beside each true statement.

    _____a. Welding tips should be selected according to the thickness of the filler rod.

    _____b. Tip sizes vary from 000 for use on 1/32" metal, up to a number 12, which can be used on metal from 3" to 4".

    _____c. Replaceable elbow tips are one-piece tips that fit onto the torch body and provide long cone flame characteristics for general purpose welding and brazing.

    _____d. Other welding tips use replaceable welding tip ends that can be easily switched for working with oxy-propane or oxy-natural gas applications.

Written Test

12. Solve problems about basic safety rules for oxyacetylene cylinders and gases. Circle the number of the best solution to each of the following.

    a. You are getting ready to attach a regulator to an oxygen cylinder, but first you need to:

        (1) Put the regulator on the acetylene cylinder.
        (2) Blow out the oxygen cylinder valve.

    b. You have placed the regulator gauges on the cylinders and are getting ready to open the cylinder valves, but first you need to:

        (1) Release the adjusting screw on the regulators.
        (2) Stand to one side.

    c. You have installed the regulator properly and now want to open the cylinder valve, but first you should:

        (1) Stand on the same side as the regulator.
        (2) Stand on the side opposite the regulator.

    d. You have done everything to set up the regulator properly, so now you can open the cylinder valve, but be sure to:

        (1) Open the valve slowly.
        (2) Open the valve all the way as quickly as you can.

    e. You are adjusting acetylene pressure and you know you must always keep one rule in mind about acetylene pressure, and that rule is:

        (1) Do not compress acetylene at pressures higher than 15 psi.
        (2) Do not compress acetylene at pressures higher than 7 psi.

Written Test

13. Complete a chart of oxyacetylene flame characteristics and uses. Place the number of the use in the appropriate blank on the chart.

Name	Characteristics	Uses
Oxidizing	Excess oxygen to acetylene burning ration with no acetylene feather, and makes a harsh, hissing sound	a. ____________
Neutral X	Burns equal amounts of oxygen and acetylene, and has a clear, clean-edged inner cone	b. ____________
Reducing X to 2X (Lightly carburizing)	Burns slightly more acetylene than oxygen, acetylene feather appears just beyond the point of the neutral flame, and is also a carburizing flame	c. ____________
Carburizing 2X to 3X	Excess acetylene to oxygen burning ration with an acetylene feather two to three times the length of the inner cone	d. ____________

1. Used for backhand welding and for welding mild steel with low-alloy rods
2. The most used flame for oxyacetylene applications
3. Used for some hardfacing, but must be used selectively because it adds carbon to base metals
4. Least used because it oxidizes metal, but is used for braze welding with a bronze rod

14. Select true statements about guidelines for flame adjustment. Place an "X" beside each true statement.

______a. To secure a neutral flame, always start with an excess of acetylene, then increase the flow of oxygen or decrease the flow of acetylene until the acetylene feather disappears from the center cone.

______b. An excess of oxygen is easy to spot, but an excess of acetylene is difficult to spot except that it will cause molten metal to spark excessively.

______c. Make sure regulator working pressures are those recommended for the tip size you are using.

______d. Beginning welders should use the harshest flame the welding torch can produce.

______e. Cut back flame length slightly when a flame is too harsh.

15. Complete statments about characteristics and causes of backfire and flashback. Circle the information that best completes each of the following statements.

    a. Backfire is a momentary (backing) (burning back) of the flame into the welding tip; it is usually accompanied by a loud (hiss) (pop).

    b. Flashback is a continued (backing) (burning back) of the flame into the tip, mixer, or torch body; it is accompanied by a loud (pop) (hiss or squeal).

    c. Overheating a tip, using a tip (too far from) (too close to) the work, or touching a tip to the work can all cause backfire or flashback.

    d. An insufficient volume of oxygen or acetylene or (incorrect) (low) gas pressures can also cause backfire and flashback.

    e. Dirty seating surfaces, leaks from loose tips, and failure to (check) (purge) the equipment can also cause backfire and flashback.

16. Complete statements about welding tip selection. Circle the information that best completes each statement.

    a. Welding tip sizes should be selected according to the thickness of the (metal to be welded) (rod size) and type of fuel gas to be used.

    b. Drill size listed with a tip indicates the size of the orifice when new so the correct size tip cleaner can be selected and the orifice can be properly checked for (wear) (performance).

    c. Tip manufacturer's recommended regulator pressures for fuel gases should not exceed the minimum or maximum recommended for a specific (size tip) (fuel gas).

    d. Tip size and regulator pressures recommended by the manufacturer should be (used on thicker metals) (carefully followed).

    e. Gas consumption data on tip selection charts are for estimating purposes, and the actual consumption will vary with the material being welded and (tip size) (operator's skill).

    f. Gas pressure recommendations on tip data charts are usually based on a hose length of (25) (10) feet, and longer lengths of hose should have about 3 psi added per each additional (25) (10) feet.

Written Test

17. Complete statements about filler rod selection, handling, and safety. Circle the information that best completes each statement.

    a. Select a rod that has the (same) (same or similar) properties of the base metal.

    b. Select a rod that is the correct size (for the thickness of the metal being welded) (for the welding tip).

    c. Keep rods (covered) (properly labeled) and stored in a clean, dry place.

    d. Keep hot filler rods away from (combustible) (electrical) materials.

    e. (Bend) (Shorten) the end of the filler rod to prevent eye injuries.

18. Select true statements about AWS designations for iron and steel gas welding rods. Place an "X" beside each true statement.

    ______a. Rods are identified with a two-letter, two-digit designation such as RG65.

    ______b. The "R" indicates a rod, the "G" indicates the rod is to be used with gas welding, and the "65" indicates manufacturer's identification number.

19. Select true statements about flux selection, handling, and safety. Place an "X" beside each true statement.

    ______a. Flux selection will always depend on the type of metal being welded, weld design, and specifications.

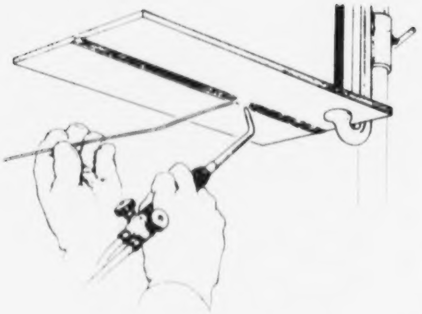
    ______b. Flux should normally be used for welding mild steel.

    ______c. After use, the lid on a tin of flux should be securely resealed before storing.

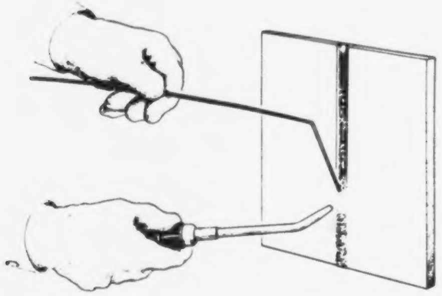
Written Test

20. Identify welding positions. Place the number of the referenced position beneath the appropriate illustration.

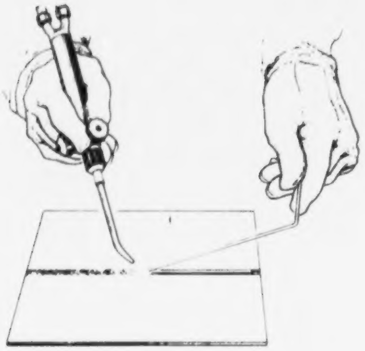
1. Position 2 or horizontal
2. Position 4 or overhead
3. Position 1 or flat
4. Position 3 or vertical



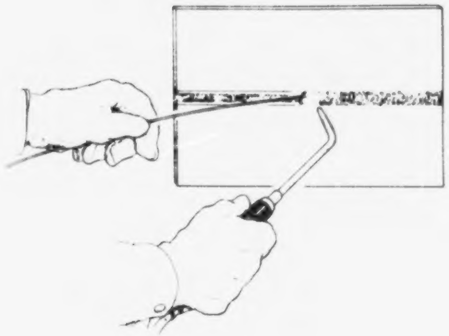
a. ____________________



b. ____________________

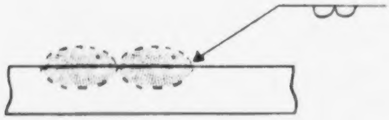


c. ______________________________



d. ______________________________

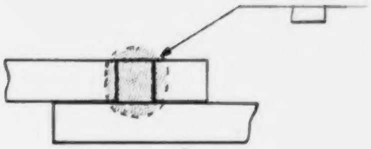
21. Identify basic types of welds and their AWS symbols. Place the number of the referenced weld type below the appropriate illustration.



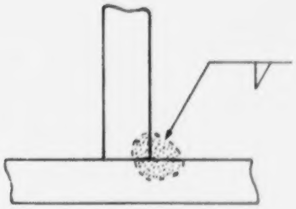
1. Plug or slot weld
2. Fillet weld
3. Beads
4. Groove weld

a. ______________________________

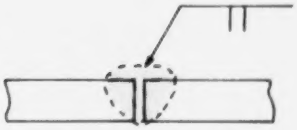
Written Test



b. ________________________________

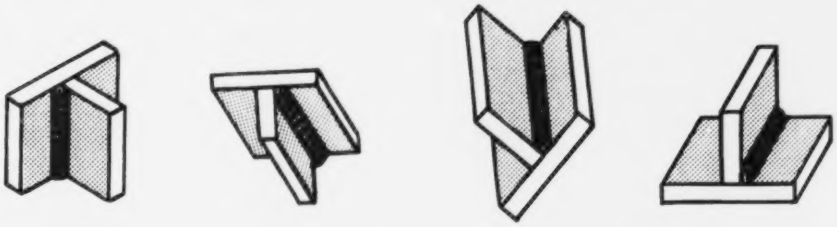


c. ________________________________



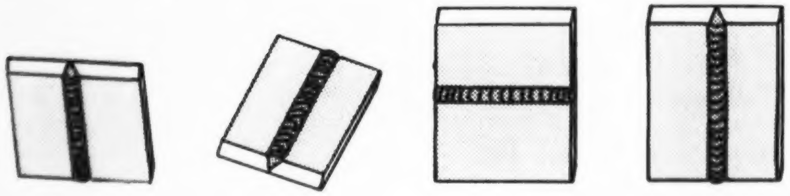
d. ________________________________

22. Identify basic welding joints and positions. Place the joint name below the appropriate illustration and list the positions in order, noting whether the welds are G or F.

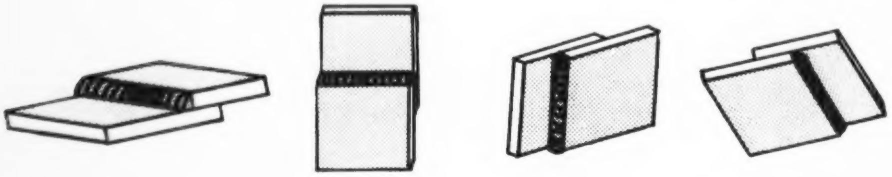


a. Joint name: ______________________ Positions left to right: ______.

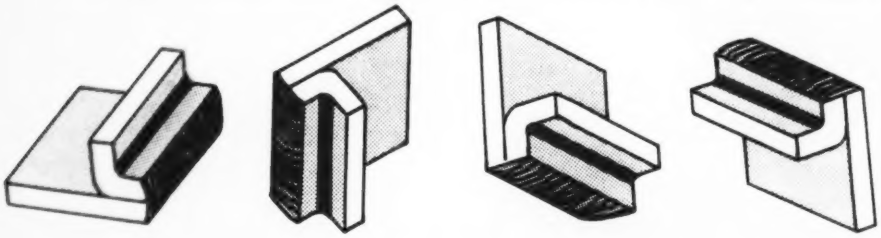
Written Test



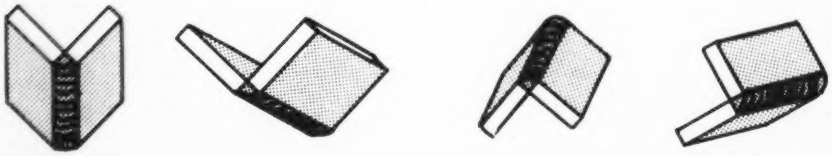
b. Joint name: ________________________ Positions left to right: ______.



c. Joint name: ________________________ Positions left to right: ______.



d. Joint name: ________________________ Positions left to right: ______.



e. Joint name: ________________________ Positions left to right: ______.

Written Test

23. Solve problems about elements of good fusion welding. Circle the number of the best solution to each of the following problems.

    a. A fellow student complains about poor weld quality and slow speed with a project being worked on. The problem could probably be corrected by:

        (1) Paying more attention to the workpiece
        (2) Paying more attention to flame and rod angles
        (3) Paying more attention to rod selection

    b. Another student is working on a welding project, and obviously has a flame-to-work distance of almost ½″. This can be corrected by:

        (1) Using a reducing flame
        (2) Adjusting flame-to-work distance to ¼″
        (3) Adjusting flame-to-work distance to ⅛″

    c. On a welding project, your rod keeps sticking to the weld and is difficult to pull loose. You can correct this problem by:

        (1) Melting the rod loose with the flame
        (2) Selecting a different size tip
        (3) Selecting a different welding rod

    d. A fellow student is working with a long welding rod in a very clumsy fasion. The problem can be corrected by:

        (1) Using a shorter rod
        (2) Bending the rod about 8″ from the end to give a better view of the weld area
        (3) Changing torch and flame angles slightly

24. Select true statements about rules of thumb for rod and torch angles. Place an "X" beside each true statement.

    ______a. The best practice for beginners is to hold both the rod and the torch at 45° angles from the surface of the workpiece to create a 90° angle between the two.

    ______b. When the torch is held at a 45° angle, it not only reduces heat input directly under the tip, but spreads heat ahead of the weld for better control.

    ______c. The flame should always be pointed or angled off to one side.

______d. The more vertical the angle of the torch flame, the more heat input under the torch tip.

______e. With experience, more vertical torch angles are helpful in certain situations, but used improperly, a more vertical torch angle usually results in burning a hole through the base metal.

25. Select true statements about guidelines for using the forehand technique in fusion welding. Place an "X" beside each true statement.

______a. For a right-handed operator, welding proceeds from right to left, but welding proceeds from left to right for a left-handed operator.

______b. The torch flame is pointed toward the unfinished end of the weld, and the filler rod is pointed toward the finished end of the weld.

26. Select true statements about guidelines for using the backhand technique in fusion welding. Place an "X" beside each true statement.

______a. For a right-handed operator, welding proceeds from left to right, but welding proceeds from right to left for a left-handed operator.

______b. The torch flame is pointed toward the finished end of the weld, and the filler rod is pointed toward the unfinished end of the weld.

______c. The backhand technique is good, and beginners should use it from the start.

27. Complete statements about techniques for controlling flame and rod motion. Circle the information that best completes each statement.

a. Keep both the flame and the filler rod in almost constant motion with the flame moving slowly forward across the line of the weld in a (side to side) (back and forth) motion as the rod moves in and out of the leading edge of the puddle.

b. Keep the motion of the rod (the same as) (opposite) the motion of the flame so that the inner cone of the flame is pointed directly at the rod for only a part of each back and forth cycle.

c. When the end of the rod is drawn away from the puddle, don't draw it away very far, but keep it in the (outer) (inner) cone of the flame.

d. Remember that puddle control can also come from the heat of the flame and rod motion because the flame (adds) (takes away) heat while the rod (takes away) (adds) heat, so control can be a product of these elements too.

Written Test

28. Select true statements about guidelines for preheating, interpass, and postheating. Place an "X" beside each true statement.

    ______a. With the exception of cast iron, preheating, interpass, and postheating in oxyacetylene welding are usually accomplished in the welding process.

    ______b. Additional preheating and postheating are usually required with aluminum.

    ______c. An oxyacetylene flame is also used for preheating, interpass, and postheating in other welding processes.

29. Select correct procedures for cleanup, inspection, and testing. Circle the number of the statement that provides the best answer to each of the following.

    a. What should happen with all welds from first to last?

       (1) They should be chipped free of slag.
       (2) They should be allowed to cool.
       (3) They should be cleaned with a wire brush until the entire weld is completely visible.

    b. Inspection should take place after every weld because with a visual inspection you can visually tell the quality of the weld, and you can also identify:

       (1) The need for cleaning the weld better.
       (2) The need for testing.
       (3) The need for a different weld sequence.

    c. A good example of nondestructive testing is:

       (1) A guided bend test.
       (2) Ultrasonic testing.
       (3) Nick-break test.

30. Arrange in order the steps in setting up cylinders and regulators. Place a 1 beside the first step, a 2 beside the second step, and other numbers in the proper order.

    ______a. Release pressure on both regulators by turning each regulator adjusting screw counterclockwise until tension is completely released on the adjusting screw.

    ______b. Stand to one side of the oxygen cylinder valve, open it momentarily and then close it quickly to purge the valve, then repeat the process for the fuel gas cylinder.

    ______c. Remove cylinder valve caps.

Written Test

_______d. Attach oxygen regulator to oxygen cylinder valve and tighten only with a cylinder wrench.

_______e. Attach fuel gas regulator to fuel gas cylinder valve and tighten only with a cylinder wrench.

_______f. Secure cylinders with a chain to a cylinder cart or wall support.

_______g. Examine cylinder valve threads for damage and wipe clean of any dust, oil, or grease with a clean, dry cloth.

31. Select true statements about steps in purging oxygen and fuel gas regulators. Place an "X" beside each true statement.

_______a. Stand to one side and open oxygen cylinder valve SLOWLY until inlet pressure gauge needle moves slowly to maximum reading, then open cylinder valve fully.

_______b. Purge oxygen regulator by turning the adjusting screw counterclockwise momentarily, then clockwise to release pressure.

_______c. Stand to one side and open fuel gas cylinder valve, and if it is an acetylene cylinder, open only one-half to three-quarters of a turn.

_______d. Purge fuel gas regulator by turning the adjusting screw counterclockwise to open it momentarily, then turn adjusting screw clockwise to release pressure.

32. Select procedures for final steps in setting up oxy-fuel equipment. Circle the number beside the best answer for each of the following situations.

a. When hoses are attached to regulators and to a torch handle, you should use:

(1) A cylinder wrench
(2) An open end wrench
(3) An adjustable wrench

b. When you're purging hoses, you need to turn each regulator adjusting screw clockwise for 3 to 5 seconds, and then you need to:

(1) Open the needle valves on the torch
(2) Start welding
(3) Turn the adjusting screws counterclockwise to release pressure

c. All threaded connections should be checked for leaks with:

(1) A leak test solution
(2) Soapy water
(3) Any kind of liquid detergent

Oxyacetylene Welding
Unit 1

Unit Evaluation Form

Student Name ________________________________ Unit Rating __________

Job Sheet 1—Light, Adjust, and Shut Down an Oxyacetylene Welding Torch in Compliance With Safety Standards Rating ______

Comments: ____

____

Job Sheet 2—Lay Beads on Flat Plate with No Filler Rod Rating ______

Comments: ____

____

Job Sheet 3—Lay Beads on Flat Plate with Filler Rod Rating ______

Comments: ____

____

Job Sheet 4—Weld an Outside Corner Joint in the Flat Position Rating ______

Comments: ____

____

Job Sheet 5—Weld a Square-Groove Butt Joint in the Flat Position Rating ______

Comments: ____

____

Job Sheet 6—Weld a Lap Joint in the Flat Position Rating ______

Comments: ____

____

Job Sheet 7—Weld a T-Joint in the Flat Position Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 8—Weld an Outside Corner Joint in the Horizontal Position Rating ______

Comments: ______

Job Sheet 9—Weld a Square-Groove Butt Joint in the Horizontal Position Rating ______

Comments: ______

Job Sheet 10—Weld a Lap Joint in the Horizontal Position Rating ______

Comments: ______

Job Sheet 11—Weld a T-Joint in the Horizontal Position Rating ______

Comments: ______

Job Sheet 12—Weld a Corner Joint in the Vertical Position Rating ______

Comments: ______

Job Sheet 13—Weld a Square-Groove Butt Joint in the Vertical Position Rating ______

Comments: ______

Job Sheet 14—Weld a Lap Joint in the Vertical Position Rating ______

Comments: ______

Job Sheet 15—Weld a T-Joint in the Vertical Position Rating ______

Comments: ______

Unit Evaluation Form

Job Sheet 16—Weld an Edge Joint in the Overhead Position Rating ______

Comments: ____

____

Job Sheet 17—Weld a Square-Groove Butt Joint in the Overhead Position Rating ______

Comments: ____

____

Job Sheet 18—Weld a Lap Joint in the Overhead Position Rating ______

Comments: ____

____

Job Sheet 19—Weld a T-Joint in the Overhead Position Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

*Permission to duplicate this form is granted.

Oxyacetylene Welding
Unit 1

Teacher Supplement 1—History of Oxyacetylene Welding and Cutting

Early History

An Englishman named Edmund Davey discovered acetylene in 1836. Eventually, acetylene was produced from calcium carbide, and this resulted in the development of acetylene as a light source. Street lights were among the earliest applications of acetylene, and by 1895, the gas was being piped and used for residential lighting in England.

Industrial Applications of Acetylene

In 1895, a French chemist discovered that acetylene and oxygen together produced a hotter flame than any other gas or combination of gases. This knowledge spawned experimentation with acetylene and oxygen in combination for welding metals together and for cutting metals. In fact, another Frenchman developed an injector-type acetylene torch in 1900. After success in Europe, the injector-type torch was introduced in America in 1906.

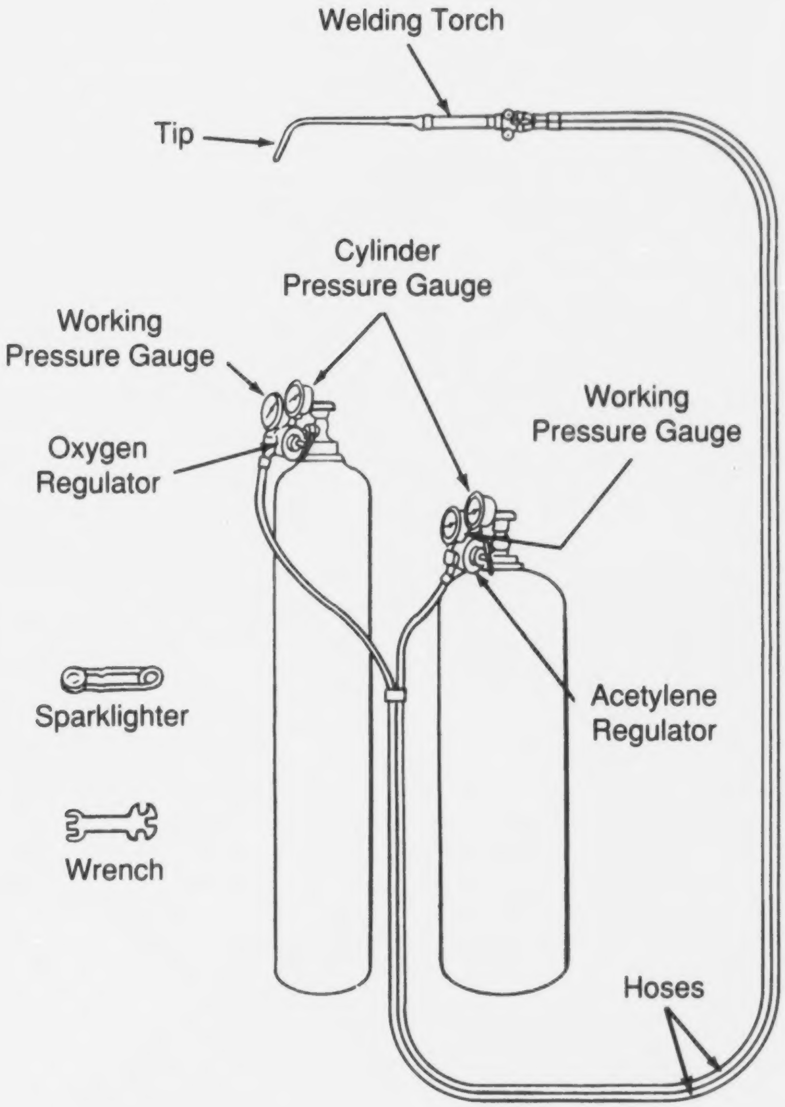
Later History of Oxyacetylene Welding and Cutting

With ongoing improvements in torch design and delivery systems for gases, oxyacetylene became the major welding process in the America of the early 1900s. The process was not only popular in industry, it spread to applications in construction, maintenance, and repair work. The popularity of oxyacetylene stemmed from the fact that the process was highly portable and could be used on almost all types of metals.

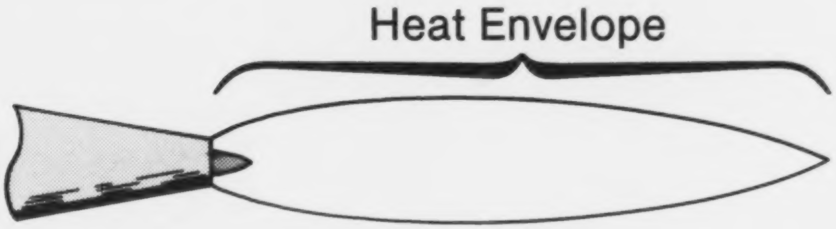
The Present and Future of Oxyacetylene Welding and Cutting

The discovery of faster arc welding processes such as GMAW (gas metal arc welding) and GTAW (gas tungsten arc welding) replaced oxyacetylene welding in many industrial applications. But the portability of oxyacetylene rigs still gives oxyacetylene and oxy-fuel systems the edge for certain applications. The systems are popular for farm equipment repair, and oxyacetylene cutting is still one of the handiest cutting processes in industry and a favorite with maintenance personnel. Total systems are relatively inexpensive, the systems are portable, and because one system can be used for both cutting and welding, the future of oxyacetylene welding and cutting is very secure.

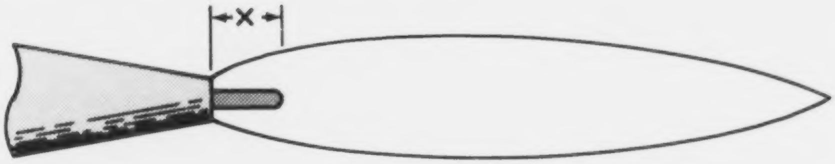
Oxyacetylene Tank and Torch Assembly


Welding Torch
Tip
Cylinder Pressure Gauge
Working Pressure Gauge
Oxygen Regulator
Working Pressure Gauge
Sparklighter
Acetylene Regulator
Wrench
Hoses

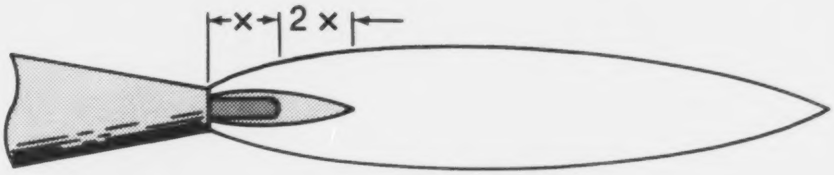
Oxyacetylene Fusion Welding Flames


Heat Envelope

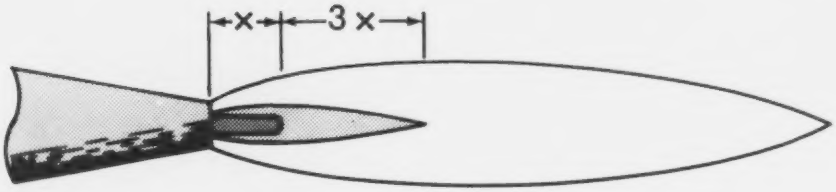
Oxidizing Flame



Neutral Flame



Reducing Flame



Carburizing Flame

Welding Tip Data

Metal Thickness	Tip Size	Drill Size	Oxygen Pressure PSIG		Acetylene Pressure PSIG		Acetylene Consumption SCFH*	
			Min.	Max.	Min.	Max.	Min.	Max.
Up to 1/32″	000	75	3	5	3	5	3/4	1 1/2
1/64″ - 3/64″	00	70	3	5	3	5	1 1/2	2 1/2
1/32″ - 5/64″	0	65	3	5	3	5	2 1/2	4
3/64″ - 3/32″	1	60	3	5	3	5	4	6
1/16″ - 1/8″	2	56	3	5	3	5	6	10
1/8″ - 3/16″	3	53	4	7	3	6	9	18
3/16″ - 1/4″	4	49	5	10	4	7	15	28
1/4″ - 1/2″	5	43	6	12	5	8	22	40
1/2″ - 3/4″	6	36	7	14	6	9	30	52
3/4″ - 1 1/4″	7	30	8	16	7	10	38	66
1 1/4″ - 2″	8	29	10	19	8	12	48	82
2″ - 2 1/2″	9	28	12	22	9	14	58	100
2 1/2″ - 3″	10	27	14	24	10	14	70	118
3″ - 3 1/2″	11	26	16	26	11	15	84	138
3 1/2″ - 4″	12	25	18	28	12	15	100	160

Gas consumption data is merely for rough estimating purposes. It will vary greatly with the material being welded and the particular skill of the operator.

Pressures are approximate for hose length up to 25 ft. Increase for longer hose lengths about 3 psi per 25 feet.

*Oxygen consumption is 1.1 times the acetylene under neutral flame conditions.

Gas Welding Rod Data

Metal	Flame Adjustment	Flux	Welding Rod
Steel, cast	Neutral	No	Steel
Steel pipe	Neutral	No	Steel
Steel plate	Neutral	No	Steel
Steel sheet	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
High carbon steel	Reducing	No	Steel
Wrought iron	Neutral	No	Steel
Galvanized iron	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
Cast iron, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron, malleable	Slightly oxidizing	Yes	Bronze
Cast iron pipe, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron pipe	Neutral	Yes	Cast iron or base metal composition
Chromium-nickel steel castings	Neutral	Yes	Base metal composition or 15-12 chromium-nickel steel
Chromium-nickel steel (18-8 and 25-12)	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium steel	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium iron	Neutral	Yes	Columbium stainless steel or base metal composition

Oxyacetylene Welding and Cutting, Unit 1
Teacher Page 41

Oxyacetylene Welding
Unit 1

Information Sheet

1. **Terms and definitions**

    a. **Base metal** — Metal to be welded, brazed, or cut

    b. **Fusion welding** — A welding process that joins metals by heating them to a melting point and allowing them to fuse or flow together

    c. **Gap wire** — A wire used for correct spacing of butt joints

    d. **Interpass heating** — Application of heat to a base metal during a welding process

    e. **Penetration** — Distance from the original surface of the base metal to that depth at which fusion stops

    f. **Postheating** — Heating after a welding operation to provide uniform cooling and stress relief

    g. **Preheating** — Heating prior to a welding or cutting operation

    h. **Stress relief** — A process whereby base metals are heated to even temperature below the critical range, held at that temperature for a given time, and uniformly cooled to avoid distortion, cracking, or other stress-related problems

    i. **Tack weld** — A short weld used to temporarily hold workpieces in place

    j. **Welding positions** — A numbered reference to the physical positioning of a workpiece with 1 as flat, 2 as horizontal, 3 as vertical, and 4 as overhead

2. **Benefits of learning oxyacetylene welding and cutting**

    a. Teaches methods used in forming, recognizing, and controlling a weld puddle

    b. Teaches methods of properly holding and manipulating welding equipment and develops techniques that are useful in other welding processes

    c. Provides practice leading to good eye-hand coordination required in the welding trade

    d. Teaches the basics of metallurgy and the characteristics of metals being welded or cut

    e. Provides a familiarity with the welding workplace and its activities

    f. Teaches a welding skill that will increase employability when facing job demands that require both arc and oxyacetylene skills

Information Sheet

3. Equipment required for oxyacetylene welding

a. Oxygen cylinder

b. Acetylene cylinder

c. Pressure regulator for oxygen

d. Pressure regulator for acetylene

e. Two hoses encased together

f. Welding torch with assorted tips

g. Welding goggles and safety glasses

h. Sparklighter

i. Check valves to prevent flashback

> **Caution: Never use a welding or cutting torch that does not have check valves.**

j. Cylinder wrench

k. Chipping hammer and wire brush

4. Safety rules for the oxyacetylene workplace

a. Keep work area free of grease, oil, and flammable materials because flying sparks can fly for several feet and cause a fire.

b. Cool or quench hot metal and extinguish all sparks before leaving the work area, but do not quench during a welding process.

c. Do not leave torches, tips, or hot metal where they can be accidentally touched by a co-worker or visitor.

d. Never carry matches or lighters filled with butane or propane into any work area where any kind of welding or cutting is taking place.

e. Do not withdraw too much volume at one time from an acetylene tank because a high demand of acetylene could withdraw acetone from the cylinder and create a hazardous condition.

Note: Two or more acetylene cylinders can be manifolded together to provide high flow rates.

Information Sheet

5. Personal safety requirements

a. Shirts — Keep collar and sleeves buttoned to keep out sparks and remove pockets from front of shirt or tape them shut if they don't have pocket flaps

b. Pants — Should have no cuffs and be long enough to come down over shoe tops

Caution: Clothes made of polyesters and other synthetics catch fire easily so it's better to wear wool or heavily-starched cottons, and frayed clothing of any kind is dangerous.

c. Welding cap — Should be worn to protect hair from sparks and spatter

Caution: Some hair sprays are highly flammable and can be ignited by sparks, and any kind of plastic hair cap or covering is dangerous in the welding area.

d. Shoes — Should have high tops of tough leather, and steel toes are recommended

Caution: Never wear sneakers, tennis shoes, or loafer-type shoes when welding.

e. Gloves — Should be leather with gauntlets

Caution: Use pliers or another suitable tool for handling hot metal because good welding gloves are expensive and it's foolish to burn them up because of bad work habits.

f. Safety glasses — Should be worn under helmets and goggles

6. Eye protection required for oxyacetylene welding

a. Wear safety glasses when cleaning or chipping base metals.

b. Wear safety glasses and a face shield when grinding joints or bevels.

Information Sheet

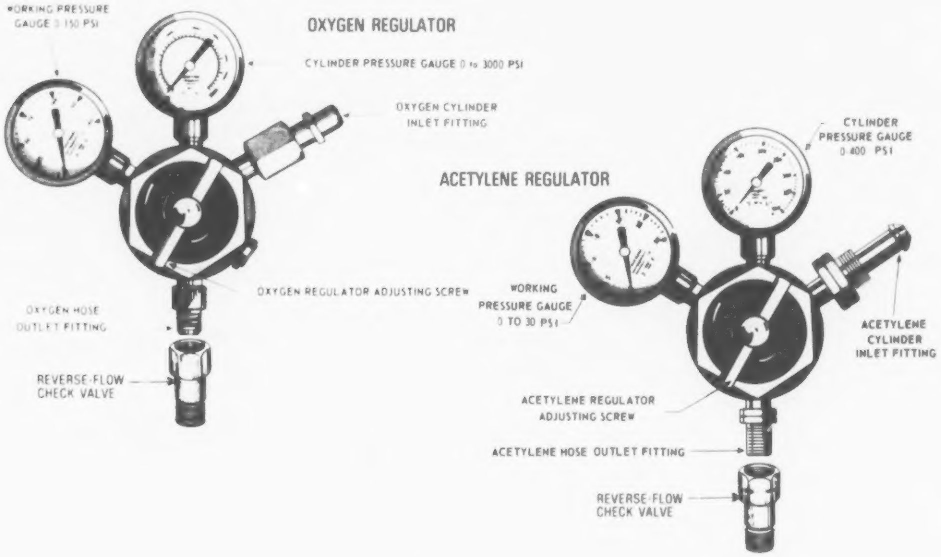
c. Wear welding goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from radiation burns.

Type of Welding	Metal Thickness	Shade #
Brazing	—	3
Light	up to ⅛″	4 or 5
Medium	⅛ - ½″	5 or 6
Heavy	½″ +	6 or 8

d. Play it safe and start with a lens shade too dark to see the work zone, then work down to a lighter shade that affords a good view of the work zone without straining your eyes.

7. **Pressure regulating valves**

a. Each regulator has two gauges mounted on a single manifold; one gauge indicates the cylinder pressure, the other indicates the working pressure for the torch.


WORKING PRESSURE GAUGE 0 150 PSI
OXYGEN REGULATOR
CYLINDER PRESSURE GAUGE 0 to 3000 PSI
OXYGEN CYLINDER INLET FITTING
CYLINDER PRESSURE GAUGE 0-400 PSI
ACETYLENE REGULATOR
OXYGEN REGULATOR ADJUSTING SCREW
WORKING PRESSURE GAUGE 0 TO 30 PSI
OXYGEN HOSE OUTLET FITTING
ACETYLENE CYLINDER INLET FITTING
REVERSE-FLOW CHECK VALVE
ACETYLENE REGULATOR ADJUSTING SCREW
ACETYLENE HOSE OUTLET FITTING
REVERSE-FLOW CHECK VALVE

b. Each regulator has an adjusting screw so pressure to the torch can be quickly controlled by turning the screw clockwise to increase pressure or counter-clockwise to decrease or completely shut off pressure.

Information Sheet

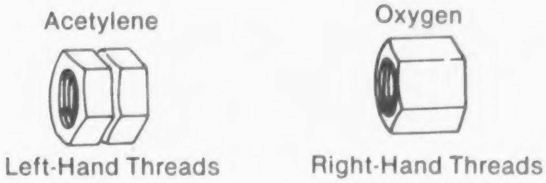
8. Welding hoses and their characteristics

a. Transport — Special nonporous hoses are used to transfer the gases from the cylinders to the torch.

b. Color — Acetylene hoses are always red; oxygen hoses are usually green, but sometimes black.

c. Connector threads — Acetylene connectors have a V-groove and left-handed threads, and oxygen connectors have plain surfaces and right-handed threads.

Note: The left-handed threads are to assure that the hoses can never be connected to the wrong cylinder.

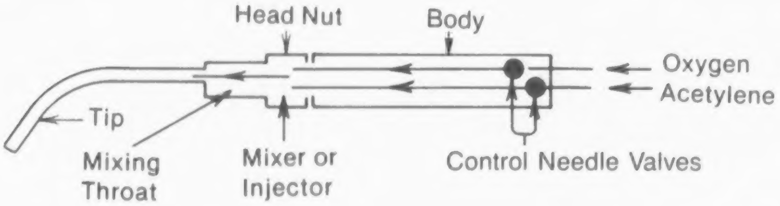

Acetylene
Oxygen
Left-Hand Threads
Right-Hand Threads

d. New hoses — New hoses are coated inside with a powder to provide storage protection; before use, the powder should be blown out by attaching each hose to the proper cylinder regulators, and opening the regulator to about five pounds of pressure.

Note: Complete the purging before you put a torch on the hoses.

9. Parts of a welding torch

a. The torch body is that part of a torch designed to be held; it contains two needle valves to control the flow of acetylene and oxygen.


Head Nut
Body
Oxygen
Acetylene
Tip
Mixing Throat
Mixer or Injector
Control Needle Valves

Courtesy Union Carbide Corporation, Linde Division

b. The welding head is the torch component that contains a mixer or injector, the mixing throat, and the welding tip to control the flame.

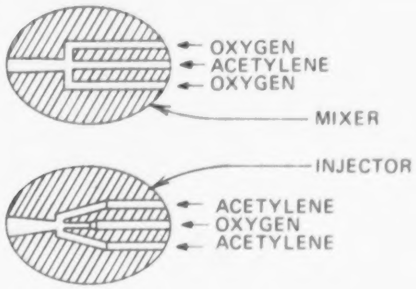
Information Sheet

10. Types of mixers and their purposes

a. Equal-pressure type — Supplies oxygen and acetylene at approximately equal pressures through a mixer; these systems are usually more fuel efficient than injector types.

b. Injector type — Supplies oxygen at a relatively high pressure and acetylene at a relatively low pressure, and can maintain normal pressure even when there are oxygen fluctuations

Note: Oxygen fluctuations sometimes occur in plant piping systems.



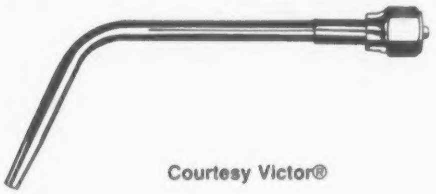
Courtesy Union Carbide Corporation, Linde Division

11. Welding tips and their uses

a. Welding tips should be selected according to the metal thickness of the workpiece.

b. Tip sizes vary from 000 for use on 1/32″ metal, up to a number 12, which can be used on metal from 3″ to 4″.

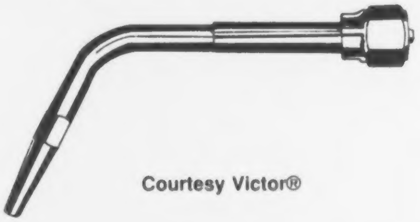
c. Replaceable elbow tips are one-piece tips that fit onto the torch body and provide long cone flame characteristics for general purpose welding and brazing.



Courtesy Victor®

Information Sheet

d. Other welding tips use replaceable welding tip ends that can be easily switched for working with oxy-propane or oxy-natural gas applications.

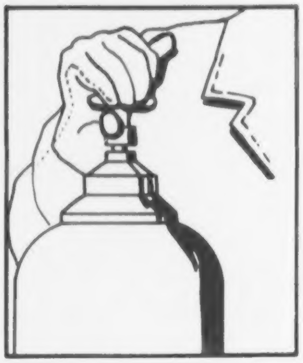


Courtesy Victor®

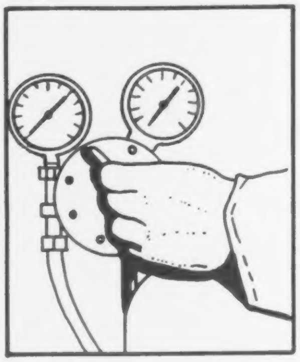
12. Basic safety rules for oxyacetylene cylinders and gases

Note: These basic rules and illustrations are courtesy of Smith's Welding Equipment.

a. Secure cylinder in a vertical position, make sure the area is clear, and blow out cylinder valves before attaching regulators.

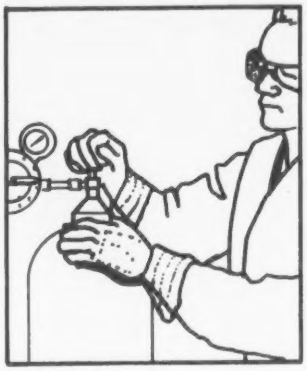


b. Release adjusting screw on regulators before opening cylinder valves.

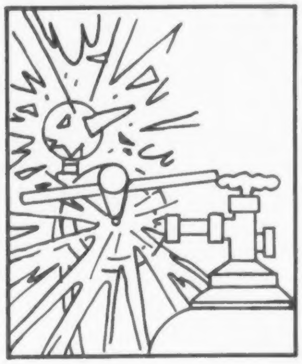


Information Sheet

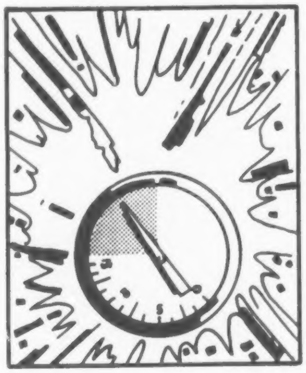
c. Stand on the side opposite the regulator when opening a cylinder valve.



d. Open cylinder valve SLOWLY.

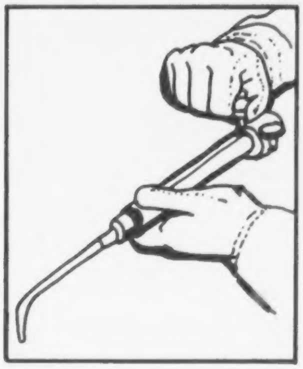


e. Do not use or compress acetylene at pressures higher than 15 psi.

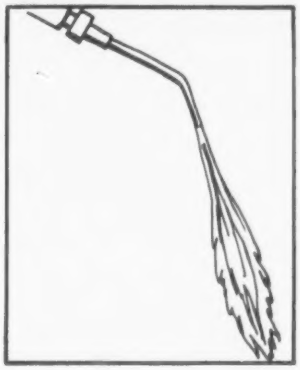


Information Sheet

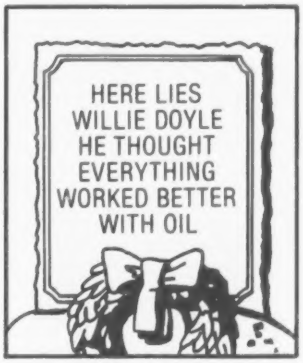
f. Purge oxygen and fuel gas lines before lighting torch.



g. Light acetylene before opening oxygen valve on torch.

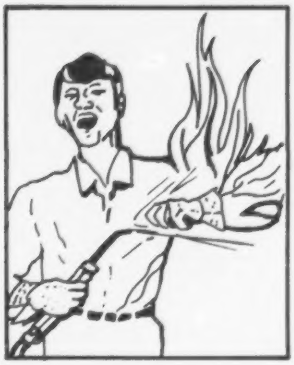


h. NEVER use oil on regulators, torches, fittings, or other equipment in contact with oxygen.

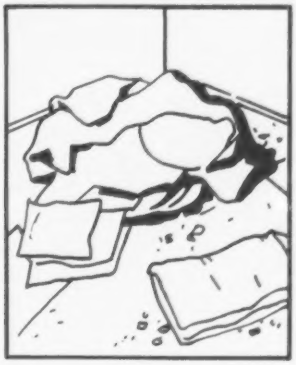

HERE LIES
WILLIE DOYLE
HE THOUGHT
EVERYTHING
WORKED BETTER
WITH OIL

Information Sheet

i. Do not use oxygen as a substitute for compressed air.



j. Keep heat, flames, and sparks away from combustibles.



Information Sheet

13. Types of oxyacetylene flames

Name	Characteristics	Uses
Oxidizing	Excess oxygen to acetylene burning ration with no acetylene feather, and makes a harsh, hissing sound	Least used because it oxidizes metal, but is used for braze welding with a bronze rod
Neutral X	Burns equal amounts of oxygen and acetylene, and has a clear, clean-edged inner cone	The most used flame for oxyacetylene applications
Reducing X to 2X (Lightly carburizing)	Burns slightly more acetylene than oxygen, acetylene feather appears just beyond the point of the neutral flame, and is also a carburizing flame	Used for backhand welding and for welding mild steel with low-alloy rods
Carburizing 2X to 3X	Excess acetylene to oxygen burning ration with an acetylene feather two to three times the length of the inner cone	Used for some hardfacing, but must be used selectively because it adds carbon to base metals

14. Guidelines for flame adjustment

a. To secure a neutral flame, always start with an excess of acetylene, then increase the flow of oxygen or decrease the flow of acetylene until the acetylene feather disappears from the center cone.

b. An excess of acetylene is easy to spot, but an excess of oxygen is difficult to spot except that it will cause molten metal to spark excessively.

c. Make sure regulator working pressures are those recommended for the tip size you are using.

d. Beginning welders should not use the harshest flame the welding torch can produce.

Note: The harshest flame is one which would separate slightly from the tip of the torch if each gas pressure were increased slightly.

e. Cut back flame length slightly when a flame is too harsh.

Note: Cutting back the flame will produce a softer flame, which is best for beginning welders because it makes welding a bit slower but affords better control.

15. Characteristics and causes of backfire and flashback

a. Backfire is a momentary backing of the flame into the welding tip; it is usually accompanied by a loud pop.

Caution: Repeated backfire indicates the potential for greater problems and the equipment should be shut down and serviced.

b. Flashback is a continued burning back of the flame into the tip, mixer, or torch body; it is accompanied by a loud hiss or squeal.

Caution: When flashback occurs, IMMEDIATELY shut off the oxygen torch valve, then the acetylene torch valve, and then SHUT THE SYSTEM DOWN COMPLETELY and check for damage. Always remember that a loud hiss or squealing sound indicates IMMEDIATE DANGER and a need for IMMEDIATE SHUTDOWN.

c. Overheating a tip, using a tip too close to the work, or touching the tip to the work can all cause backfire and flashback.

d. An insufficient volume of oxygen or acetylene or incorrect gas pressures can also cause backfire and flashback.

e. Dirty seating surfaces, leaks from loose tips, and failure to purge the equipment can also cause backfire and flashback.

16. Welding tip selection

a. Welding tip sizes should be selected according to the thickness of the metal to be welded and type of fuel gas to be used.

b. Drill size listed with a tip indicates the size of the orifice when new so the correct size tip cleaner can be selected and the orifice can be properly checked for wear.

Caution: When using a tip cleaner on an orifice, select a cleaning probe slightly smaller than the orifice, and work your way up to the proper size, but never force an oversize probe into an orifice. The small diameter probe is easy to break off in the orifice, and that renders the tip useless.

Information Sheet

c. Tip manufacturer's recommended regulator pressures for fuel gases should not exceed the minimum or maximum recommended for a specific size tip.

d. Tip size and regulator pressures recommended by the manufacturer should be carefully followed.

e. Gas consumption data on tip selection charts are for estimating purposes, and the actual consumption will vary with the material being welded and operator's skill.

f. Gas pressure recommendations on tip data charts are usually based on a hose length of 25 feet, and longer lengths of hose should have about 3 psi added per each additional 25 feet.

Metal Thickness	Tip Size	Drill Size	Oxygen Pressure PSIG		Acetylene Pressure PSIG		Acetylene Consumption SCFH*		
			Min.	Max.	Min.	Max.	Min.	Max.	
Up to 1/32"	000	75	3	5	3	5	1/4	1½	Gas consumption data is merely for rough estimating purposes. It will vary greatly with the material being welded and the particular skill of the operator. Pressures are approximate for hose length up to 25 ft. Increase for longer hose lengths about 3 psi per 25 feet.
1/64" - 3/64"	00	70	3	5	3	5	1½	2½	
1/32" - 5/64"	0	65	3	5	3	5	2½	4	
3/64" - 3/32"	1	60	3	5	3	5	4	6	
1/16" - 1/8"	2	56	3	5	3	5	6	10	
1/8" - 3/16"	3	53	4	7	3	6	9	18	
3/16" - 1/4"	4	49	5	10	4	7	15	28	
1/4" - 1/2"	5	43	6	12	5	8	22	40	
1/2" - 3/4"	6	36	7	14	6	9	30	52	
3/4" - 1¼"	7	30	8	16	7	10	38	66	
1¼" - 2"	8	29	10	19	8	12	48	82	
2" - 2½"	9	28	12	22	9	14	58	100	
2½" - 3"	10	27	14	24	10	14	70	118	
3" - 3½"	11	26	16	26	11	15	84	138	
3½" - 4"	12	25	18	28	12	15	100	160	

*Oxygen consumption is 1.1 times the acetylene under neutral flame conditions.

Information Sheet

17. Filler rod selection, handling, and safety

a. Select a rod that has the same or similar properties of the base metal.

b. Select a rod that is the correct size for the thickness of the metal being welded.

Note: The general rule is that the rod should have a diameter equal to the metal being welded, but since standard rod diameters go to only ¼", adjustments in weld design are required for certain applications.

c. Keep rods properly labeled and stored in a clean, dry place.

d. Keep hot filler rods away from combustible materials.

e. Bend the end of the filler rod to prevent eye injuries.

Note: This is especially a good rule for beginners in a school shop, and sometimes instructors have students cut the filler rods in half to minimize problems.

Metal	Flame Adjustment	Flux	Welding Rod
Steel, cast	Neutral	No	Steel
Steel pipe	Neutral	No	Steel
Steel plate	Neutral	No	Steel
Steel sheet	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
High carbon steel	Reducing	No	Steel
Wrought iron	Neutral	No	Steel
Galvanized iron	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
Cast iron, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron, malleable	Slightly oxidizing	Yes	Bronze
Cast iron pipe, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron pipe	Neutral	Yes	Cast iron or base metal composition
Chromium-nickel steel castings	Neutral	Yes	Base metal composition or 15-12 chromium-nickel steel
Chromium-nickel steel (18-8 and 25-12)	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium steel	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium iron	Neutral	Yes	Columbium stainless steel or base metal composition

Information Sheet

18. AWS designations for iron and steel gas welding rods

a. Rods are identified with a two-letter, two-digit designation such as RG65.

b. The "R" indicates a rod, the "G" indicates the rod is to be used with gas welding, and the "65" indicates the approximate tensile strength in thousands of pounds per square inch or a 65,000 pounds per square inch tensile strength.

19. Flux selection, handling, and safety

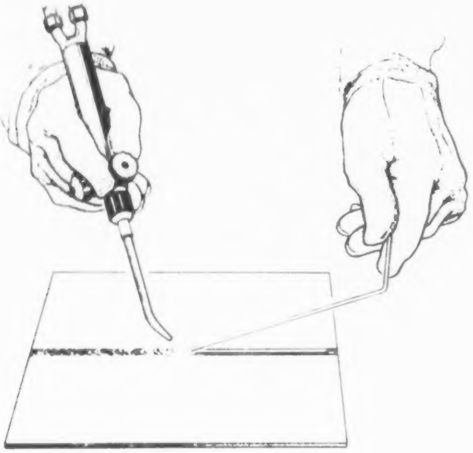
a. Flux selection will always depend on the type of metal being welded, weld design, and specifications.

b. Flux should normally be used for welding cast iron, for braze welding stainless steel and cast iron, for welding copper, aluminum, magnesium, and their alloys.

c. After use, the lid on a tin of flux should be securely resealed before storing.

20. Welding positions

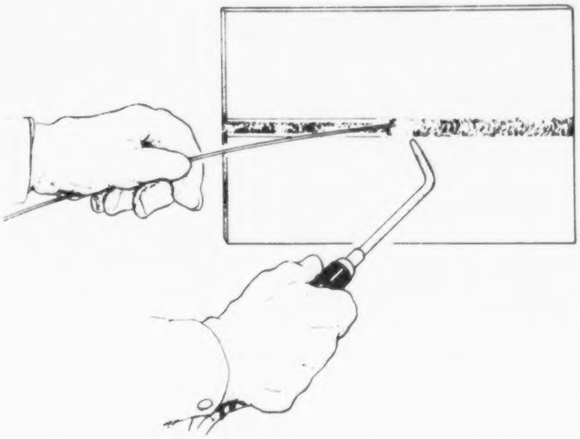
a. Position 1 or flat is an AWS designation which indicates that the surfaces of a workpiece lie parallel to the ground.



Courtesy Union Carbide Corporation, Linde Division

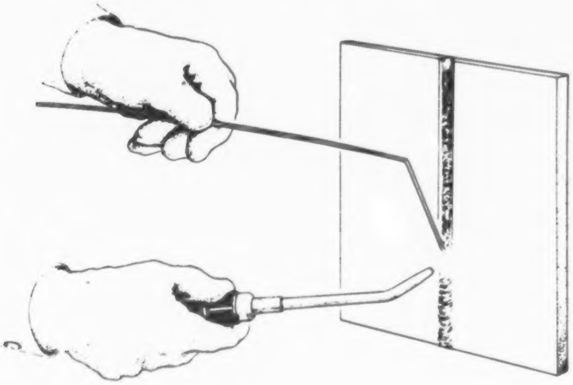
Information Sheet

b. Position 2 or horizontal is an AWS designation which indicates that the surfaces of a workpiece are parallel to the ground, but welding is perfomed below the work instead of above it.



Courtesy Union Carbide Corporation, Linde Division

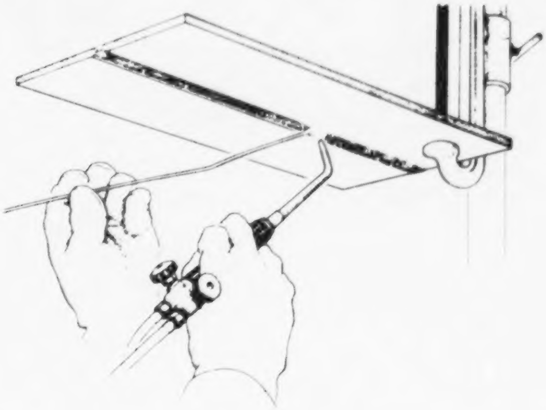
c. Position 3 or vertical is an AWS designation which indicates both surfaces of a workpiece and the line of the weld are perpendicular to the ground.



Courtesy Union Carbide Corporation, Linde Division

Information Sheet

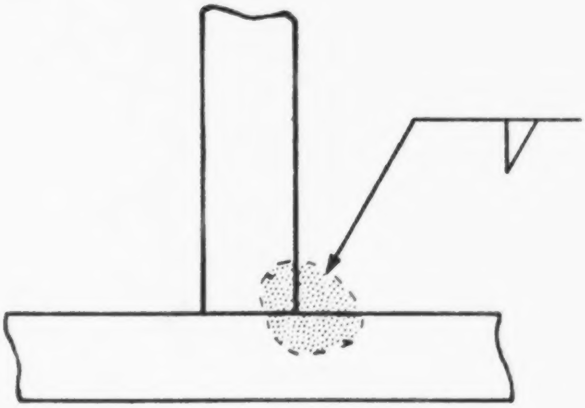
d. Position 4 or overhead is an AWS designation which indicates that the surfaces of the workpiece are parallel to the ground, but welding is performed from below the workpices instead of above it.



Courtesy Union Carbide Corporation, Linde Division

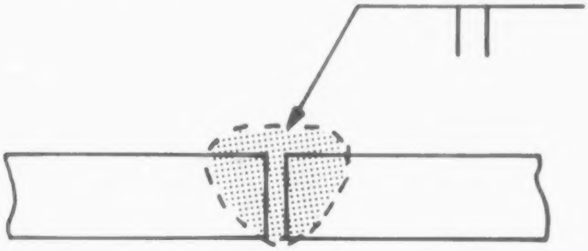
21. Basic types of welds and their AWS symbols

a. A fillet weld has the AWS designation of "F"; the fillet is a triangular-shaped weld that joins lap joints, T-joints, and corner joints.

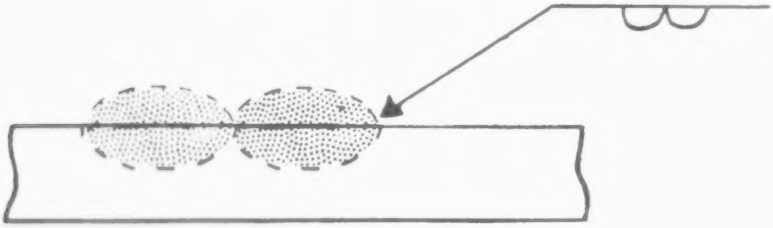


Information Sheet

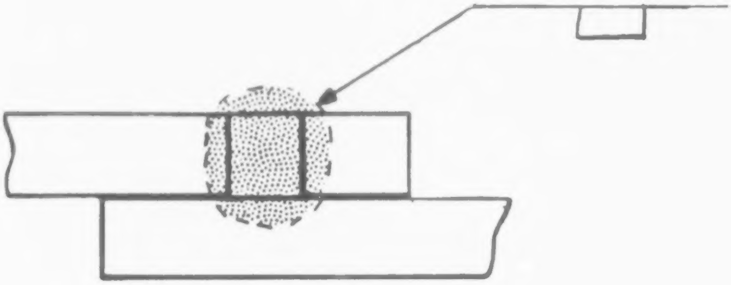
b. A groove weld has the AWS designation "G"; the groove weld is made in the goove between two pieces of metal.



c. Beads are surfacing welds made on the surface of the base metal to add to or build up the material for hardfacing and other applications.



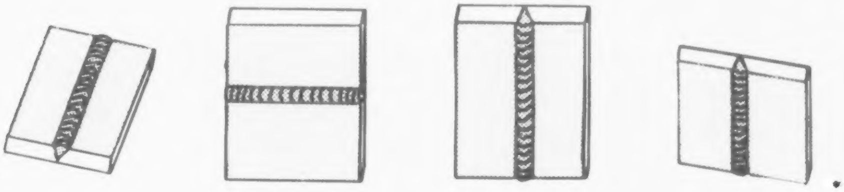
d. A plug or slot weld is a weld used to join metals by welding one member to another through a hole or slot.



Information Sheet

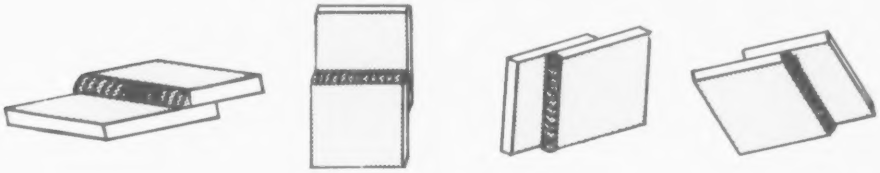
22. Basic welding joints and positions

a. Butt joint — A joint between the edges of two pieces of materials lying in the same plane



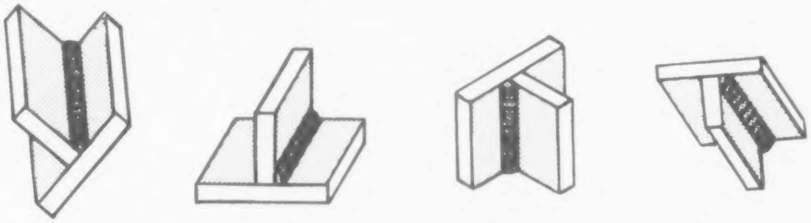
1G 2G 3G 4G

b. Lap joint — A joint made by overlapping one piece of material over another



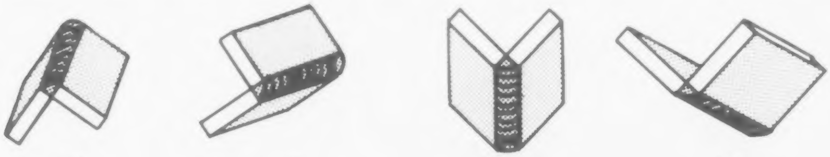
1F 2F 3F 4F

c. T-joint — A joint between two pieces of material positioned at 90° right angles to each other in the form of the letter "T"



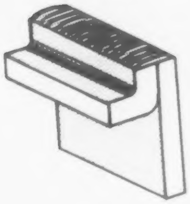
1F 2F 3F 4F

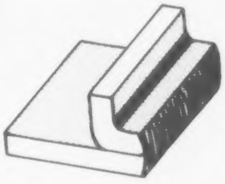
d. Corner joint — A joint between two pieces of material positioned at 90° right angles to each other to form the letter "L"

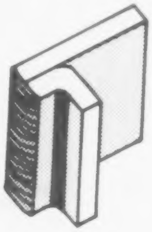


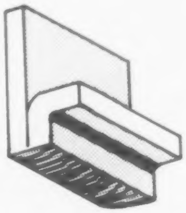
1F 2F 3F 4F

e. Edge joint — A joint between the edges of parallel plates with the end of one plate bent to form a 90° right angle above the surface of the other plate


1G


2G


3G


4G

23. Elements of good fusion welding

a. Flame and rod angles — The relative angles of the rod and the flame in relationship to the work affect welding speed and weld quality.

b. Flame-to-work distance — Normally, the tip of the flame's center cone should be kept about ⅛″ from the surface of the work or the weld puddle.

Note: With skill, welders learn to vary work distance to dig into the puddle or to back off for slower welding in difficult positions or by varying torch angle.

c. Bend in rod — Putting a bend in the rod about 8″ from the end keeps your rod hand out of the path of hot air downstream from the flame, provides better vision of the weld area, and gives better control.

Note: To bend a rod, heat it at 8″ from the end and force it against the work table or the work itself.

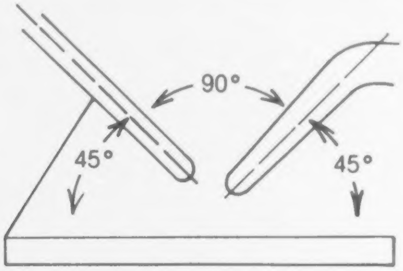
d. Rod freeze — When the rod sticks to the weld, don't try to pull it loose, but melt it loose with the flame.

e. Stub ends — Eliminate the waste of stub ends by saving and welding stub ends together or by welding another rod onto the stub end.

Information Sheet

24. Rules of thumb for rod and torch angles

a. The best practice for beginners is to hold both the rod and the torch at 45° angles from the surface of the workpiece to create a 90° angle between the two.



b. When the torch is held at a 45° angle, it not only reduces heat input directly under the tip, but spreads heat ahead of the weld for better control.

c. The flame should always be pointed along the line of the weld and not angled off to one side.

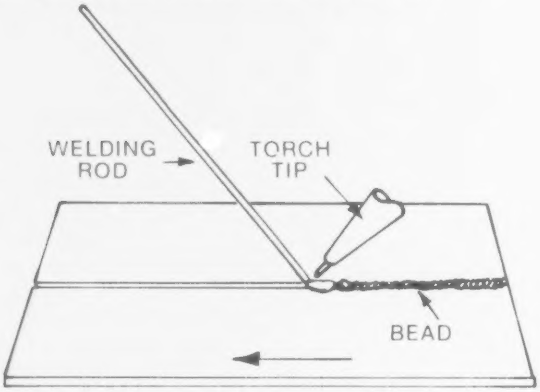
d. The more vertical the angle of the torch flame, the more heat input under the torch tip.

e. With experience, more vertical torch angles are helpful in certain situations, but used improperly, a more vertical torch angle usually results in burning a hole through the base metal.

25. Guidelines for using the forehand technique in fusion welding

a. For a right-handed operator, welding proceeds from right to left, but welding proceeds from left to right for a left-handed operator.

b. The torch flame is pointed toward the unfinished end of the weld, and the filler rod is pointed toward the finished end of the weld.



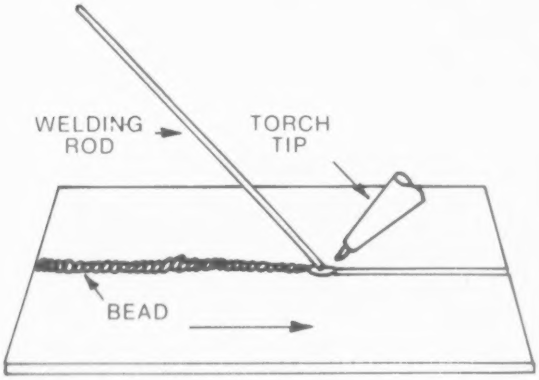
Information Sheet

26. Guidelines for using the backhand technique in fusion welding

a. For a right-handed operator, welding proceeds from left to right, but welding proceeds from right to left for a left-handed operator.

b. The torch flame is pointed toward the finished end of the weld, and the filler rod is pointed toward the unfinished end of the weld.

c. The backhand technique is good in some circumstances, but beginners should stick to the forehand technique until they develop skill.



27. Techniques for controlling flame and rod motions

a. Keep both the flame and the filler rod in almost constant motion with the flame moving slowly forward across the line of the weld in a back and forth motion as the rod moves in and put out of the leading edge of the puddle.

b. Keep the motion of the rod opposite the motion of the flame so that the inner cone of the flame is pointed directly at the rod for only a part of each back and forth cycle.

c. When the end of the rod is drawn away from the puddle, don't draw it away very far, but keep it in the outer cone of the flame.

d. Remember that puddle control can also come from the heat of the flame and rod motion because the flame adds heat while the rod takes away heat, so control can be a product of these elements too.

Information Sheet

28. Guidelines for preheating, interpass, and postheating

a. With the exception of cast iron, preheating, interpass, and postheating in oxyacetylene welding are usually accomplished in the welding process.

b. Additional preheating and postheating are usually required with cast iron.

c. An oxyacetylene flame is also used for preheating, interpass, and postheating in other welding processes.

29. Procedures for cleanup, inspection, and testing

a. Cleanup — After all welds, from first to last, the weld area should be cleaned with a wire brush until the entire weld is completely visible.

b. Inspection — After cleaning, the weld should be visually inspected to judge if it is acceptable or if its appearance indicates the need for testing.

Note: A visual inspection after each pass should be considered part of any welding procedure, and every welder should develop the habit of inspecting his or her welds to the point that it becomes an automatic reflex.

c. Testing

(1) A nondestructive test is a test that checks the quality and soundness of a weld without destroying the base metal and the weld itself.

(2) A visual test, x-ray test, magnetic particle test, and ultrasonic test are all nondestructive tests.

(3) A destructive test is a test that checks the quality and soundness of a weld by destroying the weld itself or the weld and the base metal.

(4) A guided bend test, acid etching test, and nick-break test are all destructive tests.

Note: Beginning welders should become familiar with testing procedures and your instructor will determine the type or types of testing you should use.

30. Steps in setting up cylinders and regulators

a. Secure cylinders with a chain to a cylinder cart or wall support.

b. Remove cylinder valve caps.

c. Examine cylinder valve threads for damage and wipe clean of any dust, oil, or grease with a clean, dry cloth.

Information Sheet

d. Stand to one side of the oxygen cylinder valve, open it momentarily and then close it quickly to purge the valve, then repeat the process for the fuel gas cylinder.

Caution: When purging valves or fuel lines, work area must be well ventilated.

e. Attach oxygen regulator to oxygen cylinder valve and tighten with only a cylinder wrench.

f. Attach fuel gas regulator to fuel gas cylinder valve and tighten only with a cylinder wrench.

Caution: Never use an adjustable wrench on gas fittings.

g. Release pressure on both regulators by turning each regulator adjusting screw counterclockwise until tension is completely released on the adjusting screw.

31. Steps in purging oxygen and fuel gas regulators

a. Stand to one side and open oxygen cylinder valve SLOWLY until inlet pressure gauge needle moves slowly to maximum reading, then open cylinder valve fully.

b. Purge oxygen regulator by turning the adjusting screw clockwise momentarily, then counterclockwise to release pressure.

c. Stand to one side and open fuel gas cylinder valve, and if it is an acetylene cylinder, open only one-half to three-quarters of a turn.

Caution: When a key wrench is used to open an acetylene cylinder, it should be left in place during all operations to permit rapid shutdown in case of emergency.

d. Purge fuel gas regulator by turning the adjusting screw clockwise to open it momentarily, then turn adjusting screw counterclockwise to release pressure.

Information Sheet

32. Final steps in setting up oxy-fuel equipment

a. Attach check valves to regulators.

b. Attach hoses to check valves and tighten both with an open end wrench.

Note: Check valves can be installed between the torch body and the hoses.

c. Purge both hoses by turning each regulator adjusting screw clockwise for 3 to 5 seconds, then counterclockwise to release pressure.

d. Attach hoses to torch body and tighten with an open end wrench.

e. Attach proper size welding tip to the torch body, and tighten the tip finger tight.

f. Turn torch needle valves clockwise to close them.

g. Set 5 to 10 psi on each regulator by turning the individual adjusting screws clockwise until needle on working pressure gauge reads the desired pressure.

Caution: Never exceed 15 psi on acetylene.

h. Brush leak test solution on all threaded connections to check for leaks, and if bubbles form, retighten connections with a wrench and check them again.

Note: Leak testing is best accomplished with leak detector solution because some soap contains oil.

i. Purge torch by opening fuel gas valve half a turn for 2 seconds, then closing, and repeating the procedure for oxygen.

Oxyacetylene Welding
Unit 1

Job Sheet 1—Light, Adjust, and Shut Down an Oxyacetylene Welding Torch in Compliance with Safety Standards

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment and workplace safety	______
Regulator pressure adjustments	______
Purge procedure	______
Flame start and flame adjustment	______
Shut down procedure	______

A. Tools and materials

Oxyacetylene cylinders, hoses, and torch assembly
Sparklighter
Safety glasses
Safety goggles
Welding gloves

B. Procedure

> **Caution: Do not carry a propane or butane cigarette lighter during this procedure.**

☐ 1. Inspect the workplace to make sure it is clear of flammable material and is well ventilated.

☐ 2. Put on welding goggles and welding gloves.

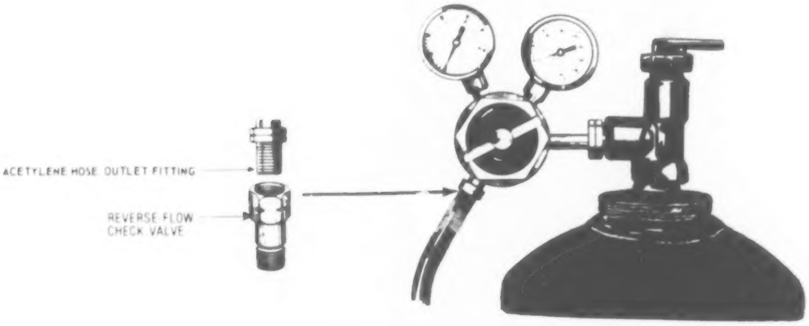
☐ 3. Inspect torch needle valves to make sure they are both turned off.

Job Sheet 1

☐ 4. Inspect both regulator adjusting screws to make sure they are turned fully counterclockwise to prevent sudden pressure from possibly damaging the regulators.

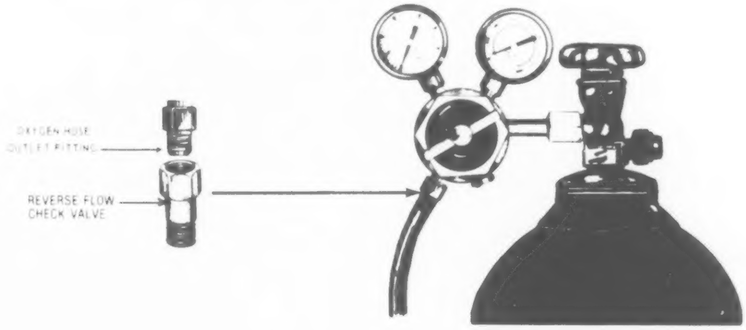
☐ 5. Open the acetylene cylinder slowly about half a turn.

Caution: Never set working pressure on an acetylene regulator gauge above 15 psi because pressure beyond that point could cause the gauge to explode.


ACETYLENE HOSE OUTLET FITTING
REVERSE FLOW CHECK VALVE

☐ 6. Tighten the adjustment screw on the acetylene regulator by turning it clockwise until the acetylene regulator indicates the recommended tip pressure.

☐ 7. Open the valve on the oxygen cylinder by slowly turning it counterclockwise as far as it will go.


OXYGEN HOSE OUTLET FITTING
REVERSE FLOW CHECK VALVE

☐ 8. Tighten the adjustment screw on the oxygen regulator by turning it clockwise until the oxygen regulator indicates the recommended tip pressure.

Job Sheet 1

☐ 9. Take the torch in your dominant hand and point the tip down and away from you into a clear, safe area.

☐ 10. Purge both lines with the following procedure:

Caution: To avoid a dangerous build-up of acetylene, only one student at a time should perform this procedure, and the area should be free of acetylene before another student attempts the purging procedure.

a. Crack the acetylene needle valve on the torch with your other hand until you hear acetylene escaping from the end of the tip.

Note: At first the acetylene will make an irregular hissing sound, then a low, steady hissing sound that indicates the acetylene line is purged.

b. Look at the acetylene regulator to make sure it remains at recommended pressure.

c. Slowly turn the acetylene needle valve on the torch off.

Note: Develop the habit of opening and closing torch needle valves with care. Forcing them quickly can damage them.

d. Repeat the same procedure with the oxygen line, and make sure the oxygen regulator remains at recommended pressure.

Note: The purging procedure gets impurities out of the lines and assures a steady flow of gases for lighting the torch.

☐ 11. Keep the torch in your dominant hand with the tip pointed down and away from you as you take the sparklighter in your other hand.

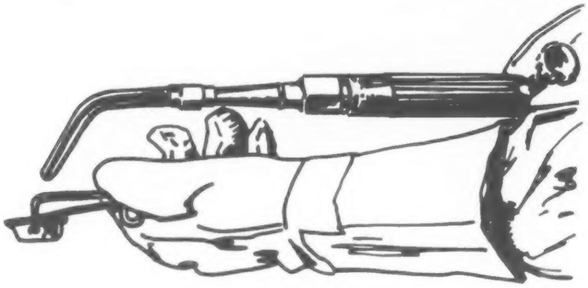
☐ 12. Open the acetylene needle valve on the torch about a quarter turn.

☐ 13. Keep the torch pointed down and away from you.

Note: Acetylene produces a black smoke when it burns, so make the following adjustments as quickly as possible.

Job Sheet 1

☐ 14. Place the sparklighter about one inch below the torch tip, and squeeze it quickly and firmly to make it spark and light the acetylene.

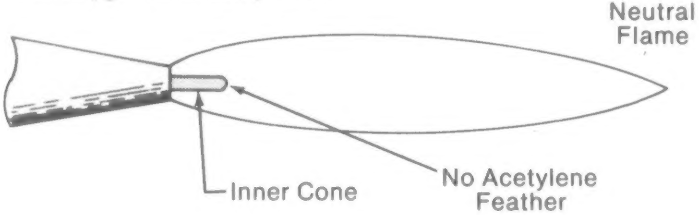


☐ 15. Open the acetylene needle valve on the torch until a blue flame appears, and carbon smoke diminishes.

☐ 16. Open the oxygen needle valve on the torch slowly to allow oxygen to mix with the acetylene.

☐ 17. Continue opening the oxygen needle valve until the mixture and pressure create a sharp inner cone of fire at the torch tip.

Note: Proper adjustment creates a neutral flame and indicates a correct mixture of oxygen and acetylene.



☐ 18. Continue moving the oxygen needle valve slowly into different positions to purposely create improper flames, then readjust for a neutral flame.

Note: This exercise should help you quickly recognize a neutral flame and the adjustments required to create and maintain a neutral flame.

☐ 19. Have your instructor check your flame and pressure settings.

☐ 20. Prepare to shut the equipment down.

☐ 21. Close the oxygen needle valve on the torch.

☐ 22. Close the acetylene needle valve on the torch.

Job Sheet 1

☐ 23. Close the oxygen valve on the cylinder.

☐ 24. Close the acetylene valve on the cylinder.

☐ 25. Open the oxygen needle valve on the torch to bleed the oxygen line.

☐ 26. Allow the oxygen regulator gauge to return to zero, then turn the oxygen regulator adjustment screw counterclockwise until spring tension is released, then close the oxygen needle valve on the torch.

☐ 27. Repeat previous steps for the acetylene line.

☐ 28. Place hoses and torch back on the welding rack and secure all equipment.

☐ 29. Have your instructor check all fuel gas and oxygen control devices.

☐ 30. Return welding goggles and welding gloves to proper storage area.

Evaluator's comments: ____

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Oxyacetylene Welding
Unit 1

Job Sheet 2—Lay Beads on Flat Plate with No Filler Rod

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Neutral flame adjustment	______
Flame manipulation and bead quality	______
Speed adjustment for heat build-up	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; secure workpiece.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

☐ 4. Put on gloves and goggles.

☐ 5. Light torch and adjust to a neutral flame according to safety standards previously outlined.

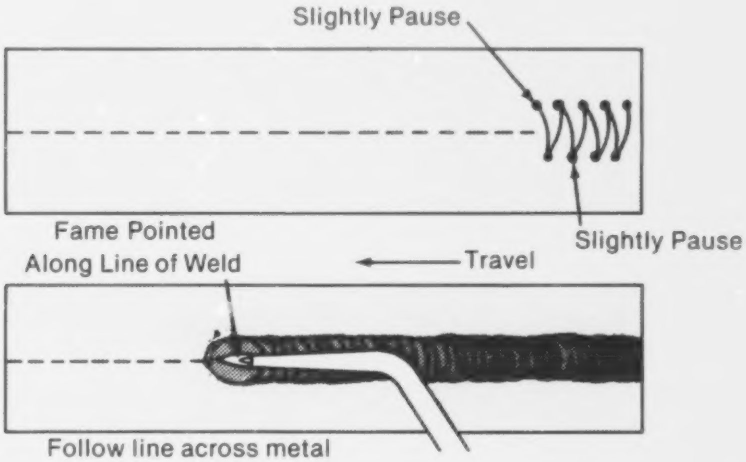
Job Sheet 2

☐ 6. Hold the torch comfortably with either hand and use the forehand welding technique to complete this job sheet.

Note: For a right-handed welder, the forehand technique travels from right to left, and for a left-handed welder, the forehand technique travels from left to right.

☐ 7. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it until a small pool of molten metal forms.

☐ 8. Move the flame back and forth in a series of short arcs or semi-circles while you advance the puddle as steadily as possible across the plate.



☐ 9. Keep puddle oval-shaped and bead as straight as possible as you continue forming the bead.

Note: A thin puddle or bead indicates welding speed is too fast, and a large, round puddle that tends to spark indicates welding speed is too slow or the tip is too close to the workpiece.

☐ 10. Begin compensating for heat build-up after you have finished the first two-thirds of the weld by increasing your welding speed slightly and as weld puddle indicates.

☐ 11. Stop before reaching the end of the weld so molten metal will not drip off the end of the plate.

☐ 12. Leave about ½″ between welds and start a second weld just below the beginning point of the first weld.

Job Sheet 2

☐ 13. Increase welding speed slightly as you finish the second weld to compensate for heat build-up in the plate.

☐ 14. Finish the second weld and continue making more welds ½" apart and parallel with welds one and two.

☐ 15. Observe puddle shape in relation to torch movement at all times and practice making the slight adjustments required in welding speed.

Note: Most beginners are up tight at this point and have white knuckles under their gloves; that's a good time to relax and concentrate completely on the manipulation of the torch and the formation of a well-shaped puddle.

☐ 16. Complete final weld and shut off torch and shut down equipment according to safety standards previously outlined.

☐ 17. Have your instructor check and evaluate your work.

☐ 18. Cool and place all welded scrap material in a proper container and clean area as required.

Note: Develop the habit of conserving materials and saving all scraps that can be used.

☐ 19. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____

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Oxyacetylene Welding
Unit 1

Job Sheet 3—Lay Beads on Flat Plate with Filler Rod

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Neutral flame adjustment	______
Torch and rod manipulation	______
Puddle shape and movement	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Secure workpiece.

☐ 3. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

☐ 4. Determine regulator pressures required; set up and purge regulators and lines.

☐ 5. Put on gloves and goggles.

Job Sheet 3

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Place the filler rod so that it is half off the work table; while holding the free end of the rod, heat the rod at the midway point until it melts in two.

Note: A shorter rod is easier for a beginner to manipulate and helps eliminate the prospects that someone might walk by and hit the back end of a longer rod and interfere with the welding or maybe injure an eye.

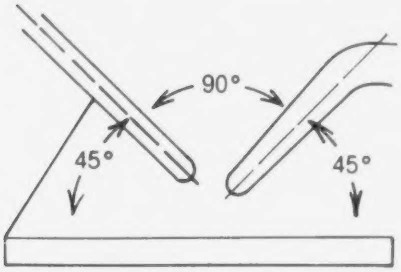
☐ 8. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

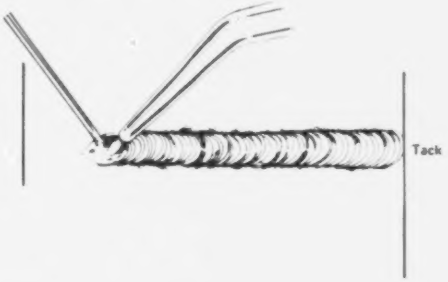
☐ 9. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 10. Move the rod into the center of the puddle at the point of the inner cone and let a drop or two of molten metal fill the puddle.

☐ 11. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

☐ 12. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle.





☐ 13. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

☐ 14. Stop before reaching the end of the plate so molten metal will not drip off the plate.

Job Sheet 3

☐ 15. Move a short distance down the plate and run another bead parallel to the first weld; continue laying parallel beads as plate space will permit.

Note: Your instructor may direct you to change hands at any point in this activity to give you the feel of working the rod and torch in different hands and to help improve your manipulative skills.

☐ 16. Cool and place all welded scrap material in a proper container and clean area as required.

☐ 17. Have instructor check and evaluate your work.

☐ 18. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 4—Weld an Outside Corner Joint in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; secure workpiece.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 4

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

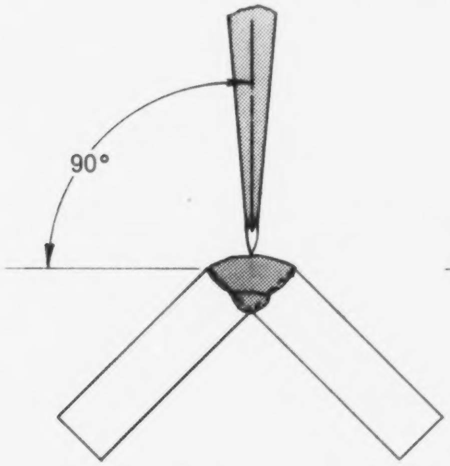
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

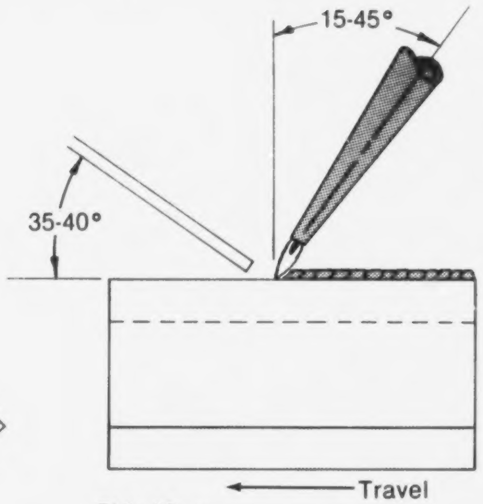
☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Front View



Side View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

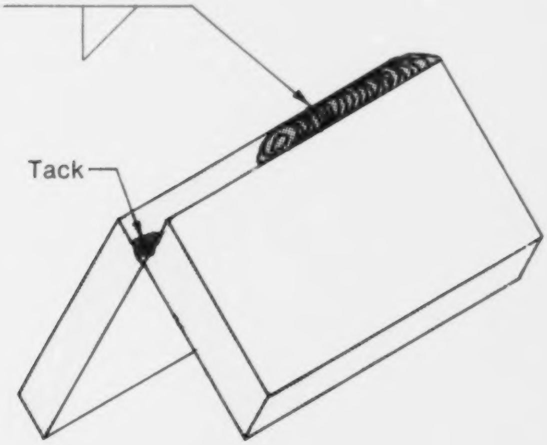
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle.

Job Sheet 4

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____

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Oxyacetylene Welding
Unit 1

Job Sheet 5—Weld a Square-Groove Butt Joint in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod for gap wire and filler metal

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; secure workpiece.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch, finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 5

☐ 4. Check joint to make sure it is properly prepared and use a welding rod as a gap wire to be sure the joint is properly fitted.

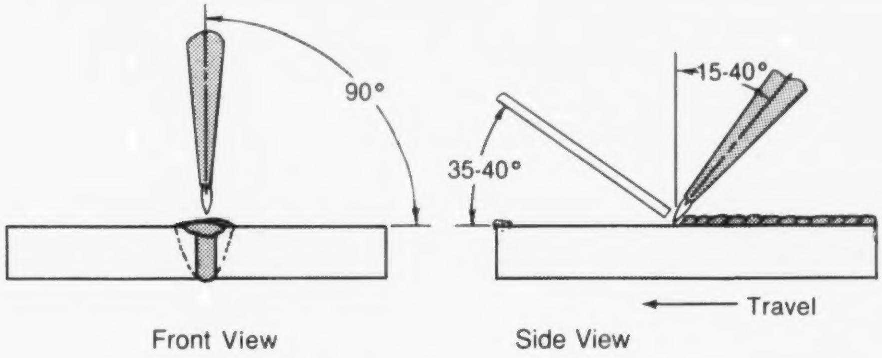
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

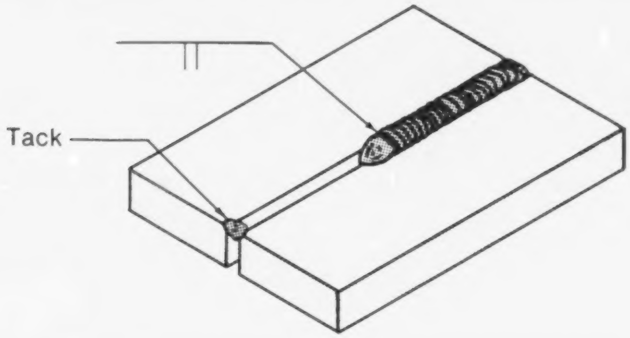
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 5

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (square groove) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Oxyacetylene Welding
Unit 1

Job Sheet 6—Weld a Lap Joint in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 6

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

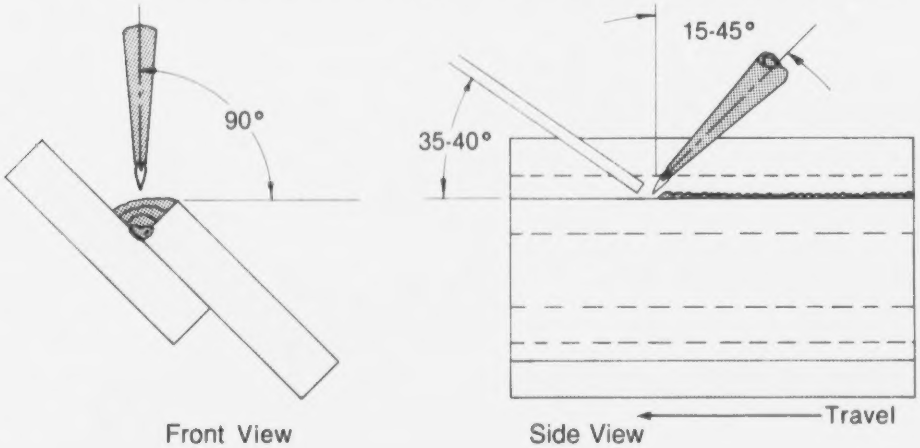
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Front View

Side View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

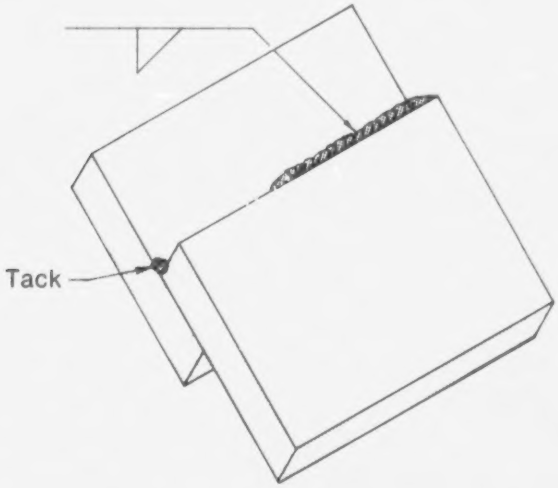
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 6

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Oxyacetylene Welding
Unit 1

Job Sheet 7—Weld a T-Joint in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 7

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

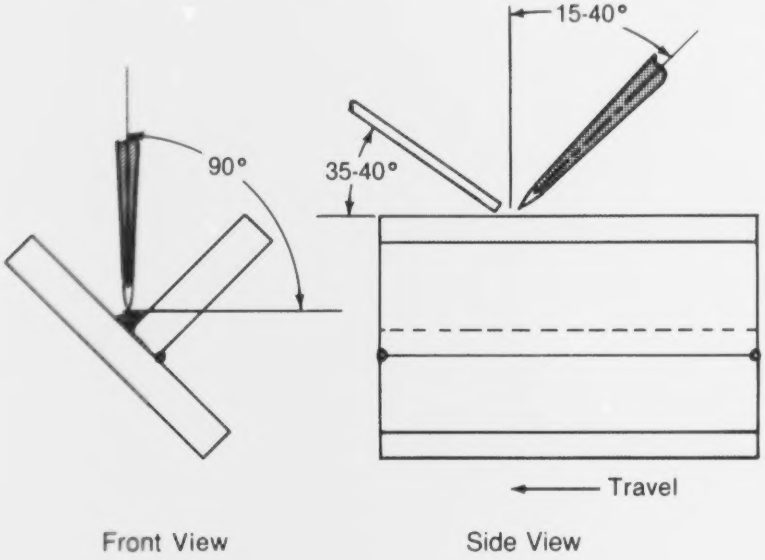
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Note: Rod is same angle as torch.

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

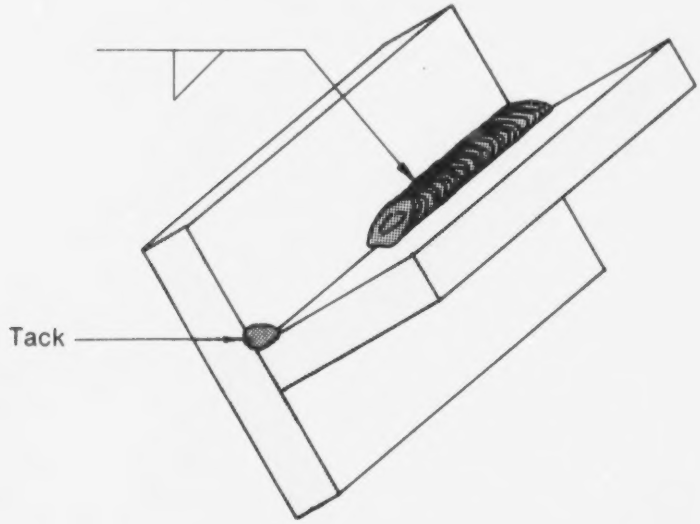
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

Job Sheet 7

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Have instructor check and evaluate your work.

Job Sheet 7

☐ 19. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

Oxyacetylene Welding
Unit 1

Job Sheet 8—Weld an Outside Corner Joint in the Horizontal Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 8

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

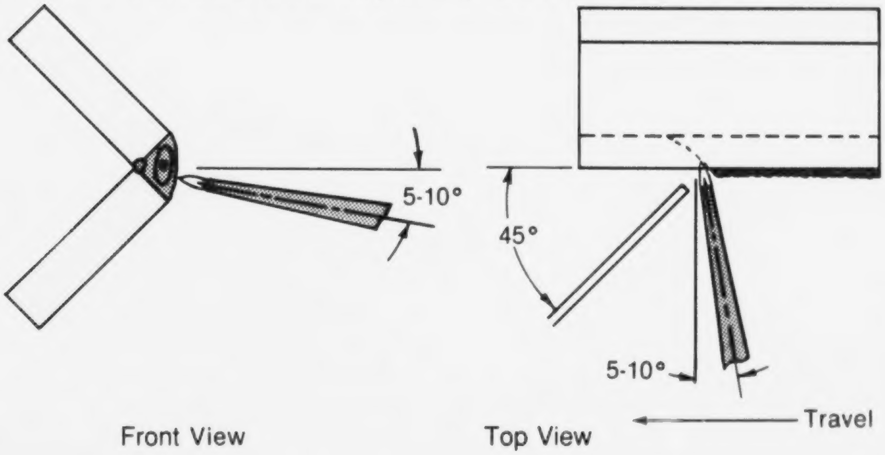
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

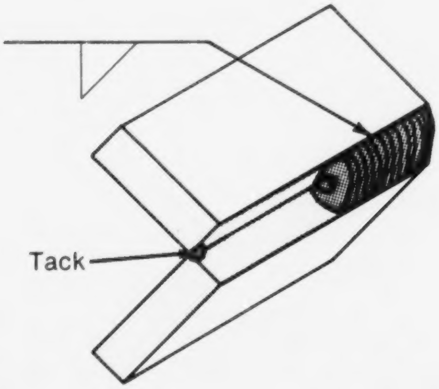
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 8

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten meta
will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 9—Weld a Square-Groove Butt Joint in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod for gap wire and filler metal

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 9

☐ 4. Check joint to make sure it is properly prepared and use the welding rod as a gap wire to assure proper fit-up.

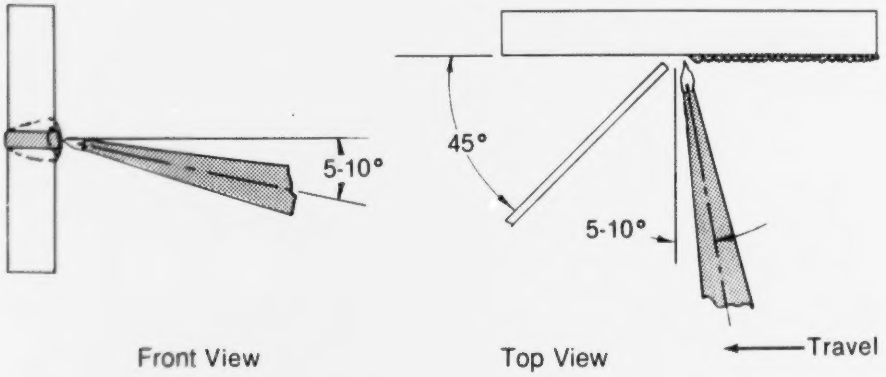
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Front View

Top View

Note: Rod is same angle as torch.

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

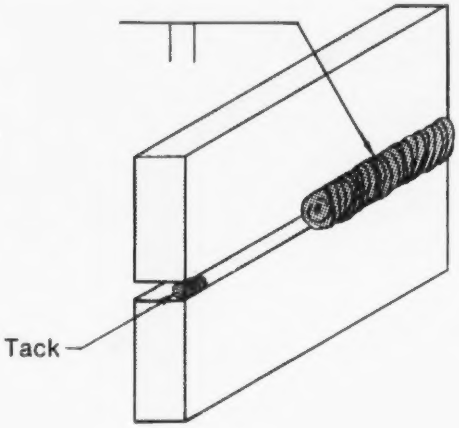
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 9

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (square groove) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 10—Weld a Lap Joint in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 10

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

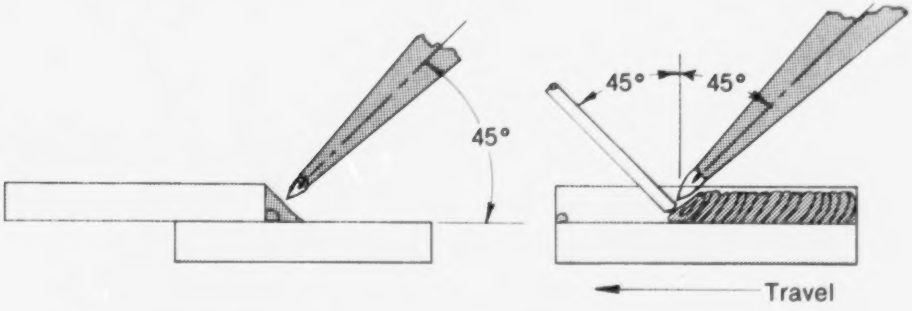
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Front View Side View

Note: Rod is same angle as torch.

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

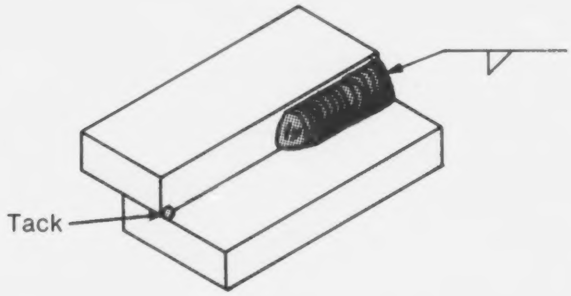
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 10

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 11—Weld a T-Joint in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	____
Joint preparation and fit-up	____
Neutral flame adjustment	____
Proper tack welds	____
Torch, rod, and puddle manipulation	____
Final bead quality	____

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 11

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

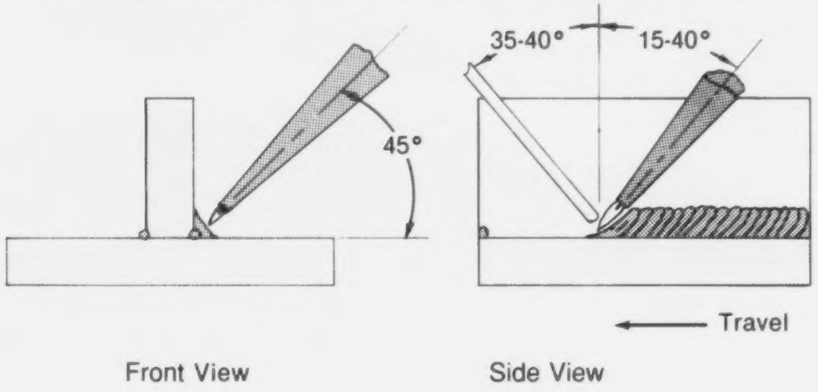
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



☐ 10. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

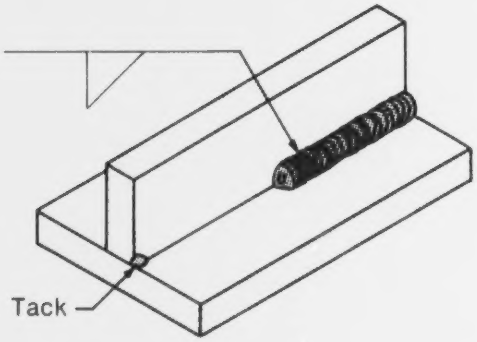
☐ 12. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 11

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 12—Weld a Corner Joint in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 12

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

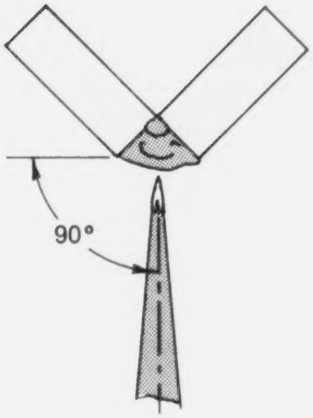
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

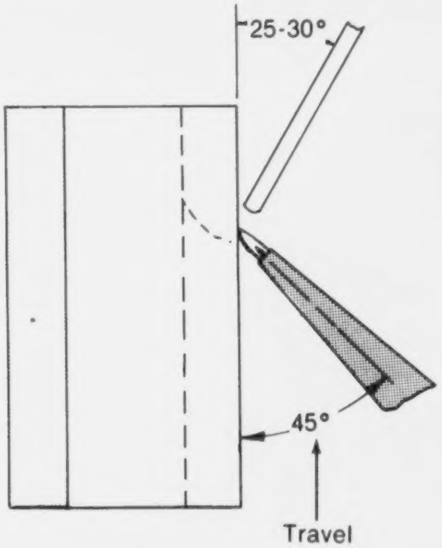
☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Top View



Side View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

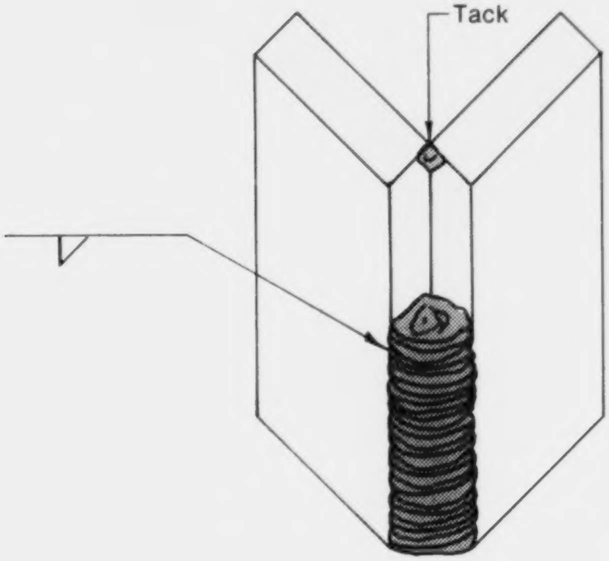
☐ 12. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

Job Sheet 12

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the plate so molten metal will not drip off the plate.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

Job Sheet 12

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

Oxyacetylene Welding
Unit 1

Job Sheet 13—Weld a Square-Groove Butt Joint in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod for gap wire and filler metal

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 13

☐ 4. Check joint to make sure it is properly prepared and use welding rod as a gap wire to assure proper fit-up.

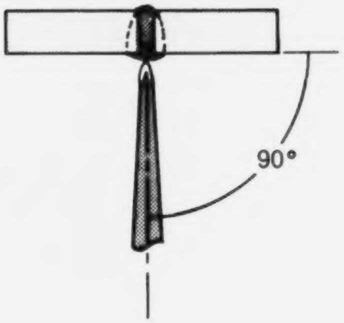
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

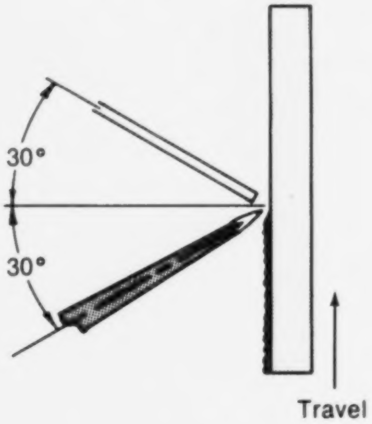
☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Top View



Side View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

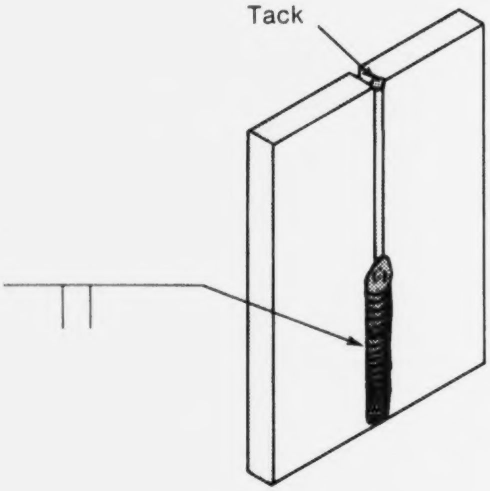
☐ 12. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

Job Sheet 13

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (square groove) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

Job Sheet 13

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 14—Weld a Lap Joint in the Vertical Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 14

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

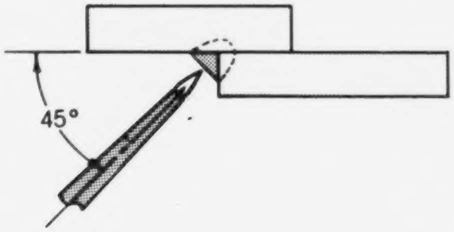
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

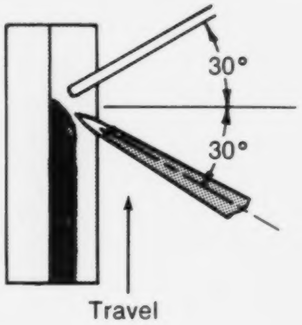
☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Top View



Side View

Note: Rod is same angle as torch.

☐ 10. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

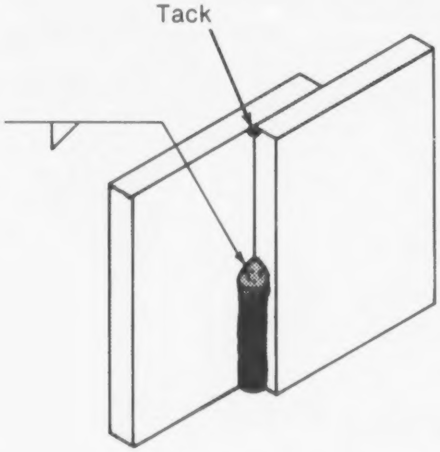
☐ 12. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

Job Sheet 14

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

Job Sheet 14

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Oxyacetylene Welding
Unit 1

Job Sheet 15—Weld a T-Joint in the Vertical Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 15

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

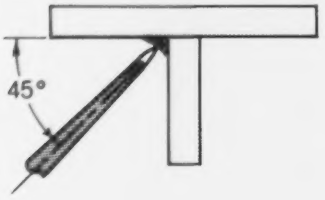
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

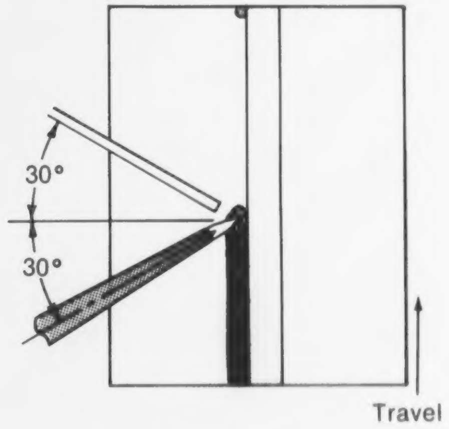
☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Top View



Front View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

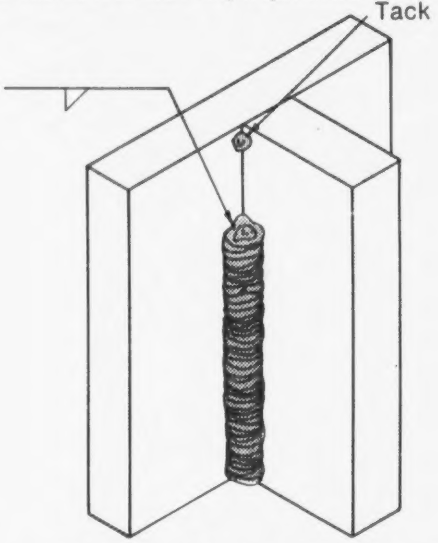
☐ 12. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

Job Sheet 15

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

Job Sheet 15

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Oxyacetylene Welding
Unit 1

Job Sheet 16—Weld an Edge Joint in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 16

☐ 4. Check joint to make sure it is properly prepared and properly fitted.

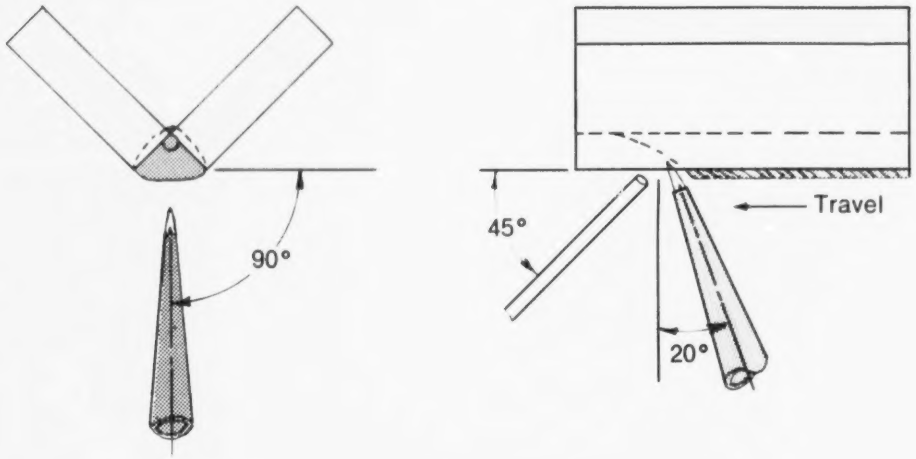
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Front View Side View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

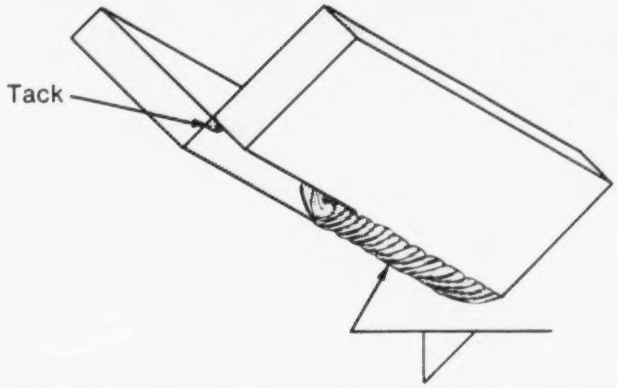
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

Job Sheet 16

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint so molten metal will not drip off the edge.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Welding
Unit 1

Job Sheet 17—Weld a Square-Groove Butt Joint in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod for use as gap wire and filler metal

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 17

☐ 4. Check joint to make sure it is properly prepared and use the welding rod as a gap wire to assure proper fit-up.

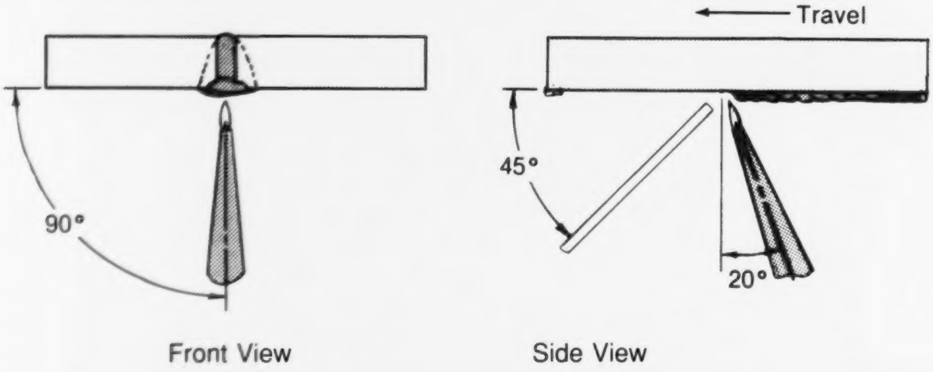
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

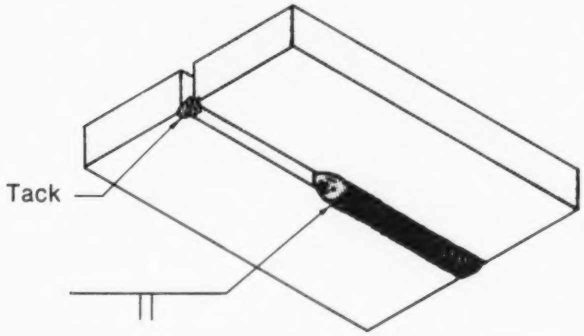
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 17

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (square groove) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Oxyacetylene Welding
Unit 1

Job Sheet 18—Weld a Lap Joint in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 18

☐ 4. Check joint to make sure it is properly prepared and use the welding rod as a gap wire to assure proper fit-up.

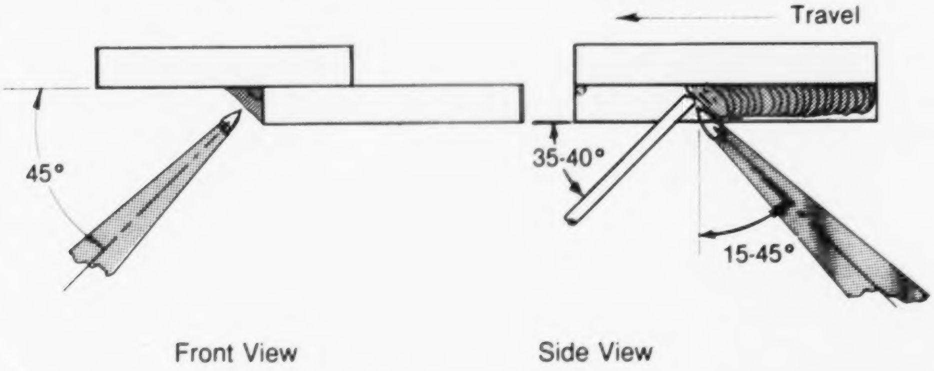
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



☐ 10. Move the torch down until the inner cone of the flame is about ⅛" from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

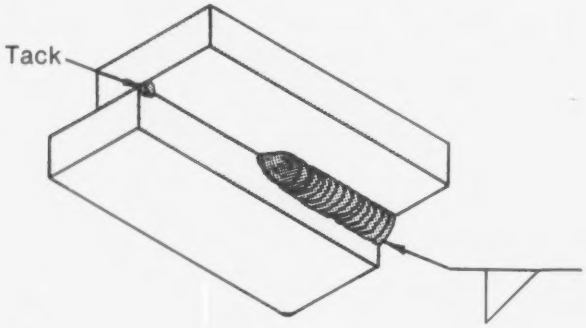
☐ 12. Withdraw the rod about ½" to ¾" from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 18

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____

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Oxyacetylene Welding
Unit 1

Job Sheet 19—Weld a T-Joint in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Equipment setup and safety	______
Joint preparation and fit-up	______
Neutral flame adjustment	______
Proper tack welds	______
Torch, rod, and puddle manipulation	______
Final bead quality	______

A. Tools and materials

Oxyacetylene welding unit
Welding gloves
Welding goggles and safety glasses
Pliers
Sparklighter
Flat plate steel workpiece as selected by instructor
Mild steel welding rod as selected by instructor

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and is well ventilated; note location of nearest fire extinguisher.

☐ 2. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight.

☐ 3. Determine regulator pressures required; set up and purge regulators and lines.

Job Sheet 19

☐ 4. Check joint to make sure it is properly prepared and use the welding rod as a gap wire to assure proper fit-up.

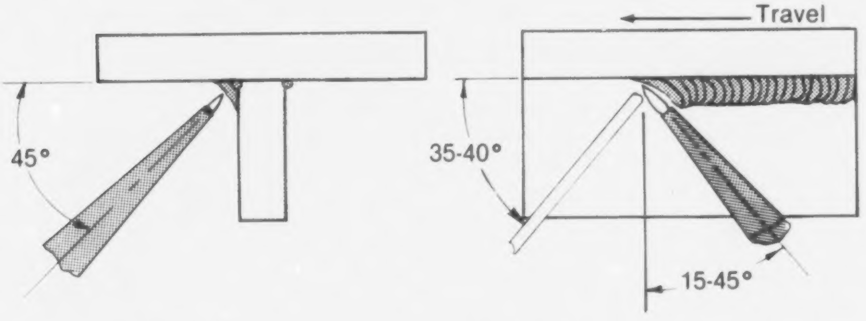
☐ 5. Put on gloves and goggles.

☐ 6. Light torch and adjust to a neutral flame according to safety standards previously outlined.

☐ 7. Hold the torch comfortably with one hand, hold the filler rod with the other hand, and use the forehand welding technique to complete this job sheet.

☐ 8. Tack weld joint at each end.

☐ 9. Position torch and rod so that the torch flame points toward the unfinished end of the weld and the rod points toward the finished end of the weld.



Front View

Side View

☐ 10. Move the torch down until the inner cone of the flame is about ⅛″ from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a slight circular motion with the torch.

☐ 11. Move the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a slight circular motion.

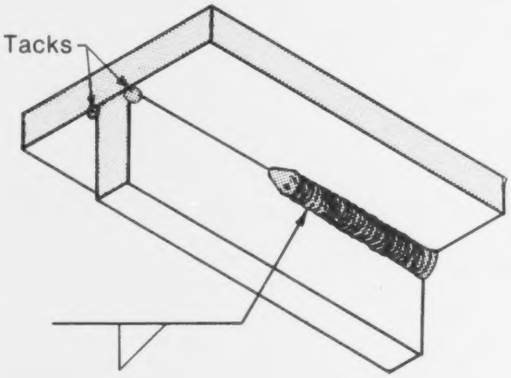
☐ 12. Withdraw the rod about ½″ to ¾″ from the inner cone so that the torch can be moved forward.

☐ 13. Advance the puddle forward with a slight circular motion of the torch and reinsert the rod into the center of the puddle at the point of the inner cone; let a drop or two of molten metal fill the puddle as you move the rod in a circular motion.

Job Sheet 19

☐ 14. Withdraw the rod, advance the torch in a circular motion so that a continuous oval-shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

Note: In the following illustration, the AWS welding symbol (a fillet weld) for this joint has been added so you can become used to associating welding symbols with the welds they represent.



☐ 15. Stop at the tack weld before reaching the end of the joint so molten metal will not drip off the edge.

☐ 16. Turn off torch.

☐ 17. Inspect weld visually for defects.

☐ 18. Test weld as directed by your instructor.

☐ 19. Have instructor check and evaluate your work.

☐ 20. Check in tools and materials, or prepare work area for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Oxyacetylene Cutting
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up, adjust, and shut down oxyacetylene cutting equipment; cut and bevel mild steel plate; cut holes and patterns in mild steel plate; bevel a pipe; and set up and cut a bevel with a track-type torch. The student will demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to oxyacetylene cutting with their correct definitions.
2. Select true statements about advantages of oxyacetylene cutting.
3. Identify parts of an oxyacetylene cutting torch.
4. Select true statements about cutting tip design.
5. Select guidelines for cutting tip selection.
6. Select true statements about guidelines for cleaning cutting tips.
7. Match tip cleaning tools with their uses.
8. Select true statements about rules for tip use.
9. Select true statements about guidelines for metal preparation for oxyacetylene cutting.
10. Arrange in order the steps for properly starting a cut.
11. Complete statements about techniques for restarting a cut.
12. Select true statements about techniques for cutting straight lines.
13. Select techniques for controlling kerf and drag.

Objective Sheet

14. Complete statements about elements of a good cut.
15. Select causes for characteristics of poor cuts.
16. Complete statements about safety requirements for oxyacetylene cutting.
17. Select true statements about characteristics of manifold systems.
18. Select true statements about characteristics of track-type cutting machines.
19. Select true statements about characteristics of shape cutting machines.
20. Select true statements about characteristics of automated cutting machines.
21. Complete statements about characteristics of pipe beveling machines.
22. Complete statements about eye protection required for oxyacetylene cutting.
23. Set up, adjust cutting flame, and shut down oxyacetylene cutting equipment. (Job Sheet 1)
24. Make 90° cuts and restart a cut on mild steel. (Job Sheet 2)
25. Make a flame-beveled cut on mild steel plate. (Job Sheet 3)
26. Cut holes in mild steel. (Job Sheet 4)
27. Lay out a pattern on mild steel plate and cut the pattern to specifications. (Job Sheet 5)
28. Cut a pipe bevel by hand. (Job Sheet 6)
29. Set up and cut a 30° bevel with a track-type torch. (Job Sheet 7)

Oxyacetylene Cutting
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Parts of a Cutting Torch (Objective 3)
   TM 2—Cutting Tip Data Chart (Objectives 4 and 5)
   TM 3—Typical Cutting Tips and Orifices (Objective 5)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss job sheets. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with the students. Discuss the rating scale that will be used for student evaluation.
13. Make copies of the written test. Add or modify test questions as needed.
14. Give written test.
15. Compile job sheet ratings and written test scores on the Unit Evaluation Form.
16. Reteach and retest as required

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD classifications have been adapted by MAVCC.

1. Review safety requirements for the general field of oxyacetylene welding and cutting, and be sure to point out to students the importance of eye safety and the need for wearing safety glasses at all times in the welding workplace.
2. Demonstrate techniques for starting a cut and restarting a cut. Provide special assistance to left-handed students because many of the procedures are written for right-handed students and simply reversing posture does not always present the best way for a left-handed person to properly cut with oxyacetylene gear. (**Learning skills**)
3. Demonstrate the use of a wraparound as is presented in Job Sheet 6, and be sure to have one available for use with the job sheet. (**Math skills**)
4. Call local industries that have welding-based activities and find out if they still have oxyacetylene equipment around and how they use it.

Resources Used in Developing This Unit

1. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
2. O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.

Suggested Activities

3. *Standard Symbols for Welding, Brazing and Nondestructive Examination (ANSI/AWS A2.4-86).* Miami, FL: American Welding Society. 1986.

4. *Victor Apparatus and Equipment Master Catalog.* Denton, TX: Victor Equipment Company, 1988.

5. *Basic Oxy-Acetylene Welding, Cutting, and Heating Practices.* New York: Union Carbide Corporation, Linde Division, 1979.

6. *Safety Meeting* (a brochure to promote the safe handling of oxy-fuel gas equipment). Watertown, SD: Smith Equipment Division, Tescom Corporation, 1985.

Suggested Supplemental Resources

1. GLA-2 "Oxyacetylene Cutting," step-by-step procedures stressing safety. 16mm film and also videocassette. Available from:

   Greater Los Angeles Chapter
   National Safety Council
   The Film Library
   3450 Wilshire Boulevard, Suite 700
   Los Angeles, CA 90010
   1-800-421-9585 or
   213-384-8114 in California

2. ITC-5 "Oxygen-Fuel Gas Cutting" covers setup, use, and cutting procedures. Videotape. Available from:

   Industrial Training Corporation
   13515 Dulles Technology Drive
   Herndon, VA 22071-3416
   1-800-638-3757 or
   703-471-1414

3. MEC-27 "Oxyacetylene Cutting Techniques" covers setup and techniques. Filmstrips with cassettes or videotape. Available from:

   Meridian Education Corporation
   Library Filmstrip Center
   236 East Front Street
   Bloomington, IL 61701
   309-827-5455

   Note: Many of the supplemental programs in "Oxyacetylene Welding," Unit 1 of this text also include materials for oxyacetylene cutting and should be referenced along with the materials listed here.

Suggested Activities

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher guide or student manual. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Oxyacetylene Cutting
Unit 2

Answers to Written Test

1. a. 3
    b. 4
    c. 1
    d. 5
    e. 2

2. a, b, d

3. a. 9
    b. 8
    c. 6
    d. 3
    e. 5
    f. 1
    g. 2
    h. 4
    i. 7

4. c, d, e

5. a. 3
    b. 2

6. b, c, d

7. a. 3
    b. 1
    c. 2

8. b, c

9. a

10. a. 1
    b. 4
    c. 2
    d. 3

11. a. Immediately
    b. Blowholes are; blowholes
        (1) Before
        (2) The original cutting line
    c. Fly in all directions

12. a, c

13. a. 2
    b. 3
    c. 1

Answers to Written Test

14. a. Square
    b. Vertical
    c. Bottom

15. a. 1
    b. 1
    c. 2
    d. 1
    e. 2

16. a. All the
    b. Shielding screens
    c. Slag
    d. Explode
    e. Can fly long distances
    f. Wastes
    g. Any container
    h. Gas cylinders

17. a, d, e

18. a, c, d

19. a, b, c

20. a, b, d

21. a. Pipe
    b. Manually operated or motorized
    c. Outside
    d. Protractors
    e. Fixed

22. a. A face shield
    b. Safety glasses and a face shield
    c. Intense light rays

Oxyacetylene Cutting
Unit 2

Written Test

Name ______________________________ Score ____________

1. Match the terms on the right with their correct definitions.

   _______a. A condition where the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

   _______b. The width of the cut produced during a cutting process

   _______c. A nonmetallic residue left after oxyacetylene cutting

   _______d. A talc-based marking pencil that has a soapy feel and is used for marking lines on workpieces

   _______e. A pliable strip of durable gasket material with edges that are perfectly straight and parallel so that it provides a guide for marking a straight line around the circumference of a pipe

   1. Slag
   2. Wraparound
   3. Drag line
   4. Kerf
   5. Soapstone

2. Select true statements about advantages of oxyacetylene cutting. Place an "X" beside each true statement.

   _______a. Oxyacetylene cutting units are readily portable and can be taken to the work, as opposed to having to bring the work to the cutting equipment.

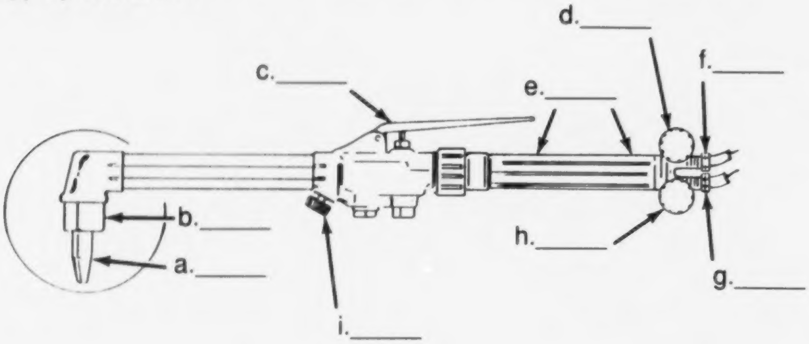
   _______b. Oxyacetylene cutting equipment is relatively inexpensive when compared to the cost of other cutting procedures.

   _______c. Oxyacetylene cutting, when properly executed, delivers a high-quality cut on aluminum.

   _______d. Oxyacetylene cutting is often done manually but can be adapted to automatic processes.

Written Test

3. Identify parts of an oxyacetylene cutting torch. Place the number of the part name in the appropriate blank.



1. Oxygen fitting
2. Acetylene fitting
3. Oxygen torch needle valve
4. Acetylene torch needle valve
5. Torch body
6. Oxygen cutting lever
7. Oxygen preheat needle valve
8. Tip nut
9. Slip-in tip

4. Select true statements about cutting tip design. Place an "X" beside each true statement.

______a. Although it is time consuming to change a cutting tip, the tips can be adapted to different thicknesses of metal.

______b. Cutting tips are designed with only one preheat orifice and only one oxygen orifice.

______c. Preheat orifices provide a mixture of oxygen and acetylene for preheating a base metal.

Written Test

______d. The single oxygen orifice directs a pressurized stream of pure oxygen onto the heated metal to accelerate the oxidation process that blows the metal away and completes the cut.

______e. Oxyacetylene cutting tips have to be tightened with a wrench.

5. Select guidelines for cutting tip selection. Circle the number of the best answer to each of the following situations.

   a. A co-worker is just beginning a job. When selecting the cutting tip, the worker should consider:

      (1) Using as new a tip as possible.
      (2) How fast the job done must be finished.
      (3) Picking a tip recommended for the thickness of the material to be cut.

   b. If a co-worker complains about slow cutting speed, the problem could easily be:

      (1) Fuel pressures are set too high
      (2) A different size tip is required because the cutting tip definitely affects cutting speed.
      (3) He or she is holding the torch too far away from the workpiece.

6. Select true statements about guidelines for cleaning cutting tips. Place an "X" beside each true statement.

______a. Because cutting tips inevitably pick up carbon and/or slag, clean cutting tips monthly.

______b. Always select a cleaning probe smaller than the orifice to be cleaned; never force too large a cleaning prove into an orifice.

______c. Take special care not to break the cleaning probe off inside an orifice.

______d. Be careful with the seating edges of cutting tips because some of them can be easily damaged.

Written Test

7. Match tip cleaning tools with their uses. Place the tool number beside the explanation of its use.

______a. A miniature drill; used for cleaning and reconditioning orifices

______b. A device with a series of small file-like probes that are gauged to match specific orifice openings; used to remove carbon buildup inside the tip

______c. A circular-shaped device with small steel cutting blades inset so it can be placed over the entire end of the tip; used to both clean and restore the face of the tip

1. Tip cleaner
2. Tip nip
3. Tip drill

8. Select true statements about rules for tip use. Place an "X" beside each true statement.

______a. Use a tip as a hammer to chip slag off a cut only when you really have to.

______b. Never try to clean a tip by rubbing it on fire brick or against anything not designed for tip cleaning.

______c. Never use an oily or greasy wrench to tighten a cutting tip, and never use an oily rag to clean dirt from a tip.

9. Select true statements about guidelines for metal preparation for oxyacetylene cutting. Place an "X" beside each true statement.

______a. For all critical cutting that requires following layout lines, burn metal free of oil and grease.

______b. Remove scale and rust with a grinder.

10. Arrange in order the steps for properly starting a cut. Place a 1 beside the first step and number the following steps in order.

______a. Place the cutting tip so that the preheat flame is half on the metal and half off the edge of the metal, and the tip is perpendicular to the metal surface.

______b. When cutting starts, tilt the cutting tip slightly in the direction of the cut and move the tip at a constant speed along the cut line.

Written Test

______c. Place the tips of the preheat inner cones as close as possible to the metal without touching it.

______d. Preheat the starting point until the metal is cherry red, then depress the oxygen cutting lever.

11. Complete statements about techniques for restarting a cut. Circle the information that best completes each statement.

    a. Anytime cutting stops, release the oxygen cutting lever (slowly) (immediately), preheat the restarting point at the edge only, and start again as if beginning a cut.

    b. (Blowholes are) (Slag is) the biggest problem with restarting a cut, and (blowholes) (slag) can be avoided by if you:

        (1) Stop torch travel (after) (before) releasing the oxygen cutting lever.

        (2) Move the torch into the scrap area beyond the cutting line to form a corner or a curl about ¼" long so the cut can be restarted in the scrap area and moved cleanly back to (the original cutting line) (a new cutting line).

    c. Avoid cutting across slag when restarting because the slag will (fly in all directions) (explode) and create a hazard.

12. Select true statements about techniques for cutting straight lines. Place an "X" beside each true statement.

______a. Hold the torch in your right hand with your thumb on the cutting lever and the torch centered in front of your body.

______b. Support the torch in your left hand with a firm grip that will not allow the torch to drift.

______c. As you move the torch along the cutting line, roll your left hand slightly to the left from time to time to make the adjustment required to keep the cutting flame straight along the line.

Written Test

13. Select techniques for controlling kerf and drag. Circle the number of the statement that provides the best answer to each of the following situations.

    a. Good oxyacetylene cutting requires proper tip selection and proper travel speed, but another important element is:

        (1) Metal thickness.
        (2) Proper fuel gas pressures.
        (3) Proper layout.

    b. The thickness of the metal being cut determines tip selection and fuel gas pressures, but another important element is:

        (1) Length of fuel gas hoses.
        (2) Workplace environment.
        (3) Torch angle.

    c. As a general rule, torch angle should vary with:

        (1) The thickness of the metal being cut.
        (2) The type of tip selected.
        (3) Settings of fuel gas pressures.

14. Complete statements about elements of a good cut. Circle the information that best completes each statement.

    a. The edge is (square) (sharp)

    b. Drag lines are (vertical and clean) (straight and deep)

    c. There is no adhering slag at the (bottom) (top) edge of the cut

15. Select causes for characteristics of poor cuts. Circle the number of the information that best identifies the causes for the following characteristics of poor cuts.

    a. Bad gouging at the bottom of a cut indicates that:

        (1) The preheat flame was not hot enough.
        (2) The preheat flame was too hot.

    b. A melted top surface and excessive adhering slag indicates:

        (1) The preheat flame was too hot.
        (2) The preheat flame was not hot enough.

c. Several things can cause a cut to get completely out of control, but more than likely it is that:

(1) Acetylene pressure is too low.
(2) Oxygen pressure is too high and the tip size too small.

d. When irregularities are prominent in the drag line, it usually means that:

(1) Cutting speed was too slow.
(2) Cutting speed was too fast.

e. A pronounced break in the drag line and an irregular cut edge usually indicates that:

(1) Cutting speed was too slow.
(2) Cutting speed was too fast.

16. Complete statements about safety requirements for oxyacetylene cutting. Circle the material that best completes each statement.

a. When oxyacetylene cutting, follow (all the) (setup) rules that apply to safe oxyacetylene welding.

b. Because higher oxygen pressures create showering sparks, use (shielding screens) (lower pressures) to protect nearby areas.

c. Perform cutting on a proper cutting table that provides a work area with a grated surface that permits slag to drop through into a (slag) (scrap) box.

d. Do not cut or weld on a masonry floor because moisture trapped in the masonry can heat rapidly and cause the floor to (explode) (crack).

e. Because cutting sparks (are dangerous) (can fly long distances), move flammable materials a safe distance from the cutting area.

f. Do not set oxygen pressure too high; too high a setting causes sparks to blow and (consumes) (wastes) oxygen too.

g. Do not cut into (a barrel) (any container) because it may still contain the residue of highly explosive materials.

h. Keep cutting as far away from (gas cylinders) (other work areas) as hose length will permit.

Written Test

17. Select true statements about characteristics of manifold systems. Place an "X" beside each true statement.

_______a. Manifolds are systems that pipe oxygen and acetylene from two or more oxygen or acetylene tanks to provide a continuous gas supply when only one cylinder would be inadequate.

_______b. A manifold system should be large enough to supply volume for the smallest size tip used.

_______c. A manifold should be equipped with a water seal flash arrester on the oxygen side.

_______d. Manifold systems save space when a number of work stations are required.

_______e. Manifold systems permit a school or shop to buy gases in quantity, reduce costs, and save money.

18. Select true statements about characteristics of track-type cutting machines. Place an "X" beside each true statement.

_______a. Track-type cutting machines require setup, alignment, and adjustment by an operator.

_______b. Track-type machines operate on tracks mostly designed for horizontal cutting, and none can cut in the overhead position.

_______c. The carriage is motor-driven and speed is controlled by a governor.

_______d. Some track-type machines have provisions for mounting two or more torches.

_______e. Track-type machines are use mostly for making square or beveled cuts, and cannot be modified to cut circles.

19. Select true statements about characteristics of shape cutting machines. Place an "X" beside each true statement.

_______a. Machines vary in design from a single wheel to three wheels with attachments for cutting straight lines, bevels, circles, and irregular shapes.

_______b. Machines are adjustable to many steel forms including rod and pipe, and can be used to cut horizontally or vertically.

_______c. Machines are controlled by operators who control the speed and direction of a cutting torch that is centered in front of or beside a drive mechanism.

Written Test

20. Select true statements about characteristics of automated cutting machines. Place an "X" beside each true statement.

    ______a. Automated cutting machines are usually designed for a specific job where the cutting of multiple identical shapes contributes to high productivity.

    ______b. Automated machines function as tracing devices that use a photocell or an electric eye to trace a pattern, or use magnetic devices to trace a metal template.

    ______c. These machines usually require manual torch movement to give an operator precise control over gas torch operations.

    ______d. These machines are sometimes programmed numerically with punched tape fed into a master control unit, but they are sometimes controlled with solid state digital devices such as a computer or a programmable logic controller.

21. Complete statements about characteristics of pipe beveling machines. Circle the material that best completes each statement.

    a. Pipe beveling machines are designed specifically for cutting beveled angles, T's and Y's, and other connecting shapes for (pipe) (pipe and plate).

    b. Beveling machines may be (manually operated or motorized) (manually operated only).

    c. The basic machine design is a split horseshoe that fits the (inside) (outside) contour of the pipe and is then clamped into position for cutting.

    d. Torch holders are designed with easy-to-read (pre-set angles) (protractors) for precise control of the cutting angle.

    e. A variation of the pipe beveling machine is a device that turns the pipe while the torch holder remains (fixed) (partially fixed) instead of working around the pipe.

22. Complete statements about eye protection required for oxyacetylene cutting. Circle the material that best completes each of the following statements.

    a. Wear (a face shield) (safety glasses) when cleaning or chipping slag from base metal.

    b. Wear (safety glasses) (safety glasses and a face shield) when grinding joints or bevels.

    c. Wear welding and cutting goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from (heat burns) (intense light rays).

Oxyacetylene Cutting
Unit 2

Unit Evaluation Form

Student Name ________________________ Unit Rating __________

Job Sheet 1—Set Up, Adjust Cutting Flame, and Shut Down Oxyacetylene Cutting Equipment Rating ______

Comments: ____

____

Job Sheet 2—Make 90° Cuts and Restart a Cut on Mild Steel Rating ______

Comments: ____

____

Job Sheet 3—Make a Flame-Beveled Cut on Mild Steel Plate Rating ______

Comments: ____

____

Job Sheet 4—Cut Holes in Mild Steel Rating ______

Comments: ____

____

Job Sheet 5—Lay Out a Pattern on Mild Steel Plate and Cut the Pattern to Specifications Rating ______

Comments: ____

____

Job Sheet 6—Cut a Pipe Bevel by Hand Rating ______

Comments: ____

____

Job Sheet 7—Set Up and Cut a 30° Bevel with a Track-Type Torch Rating ______

Comments: ____

____

Unit Evaluation Form

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

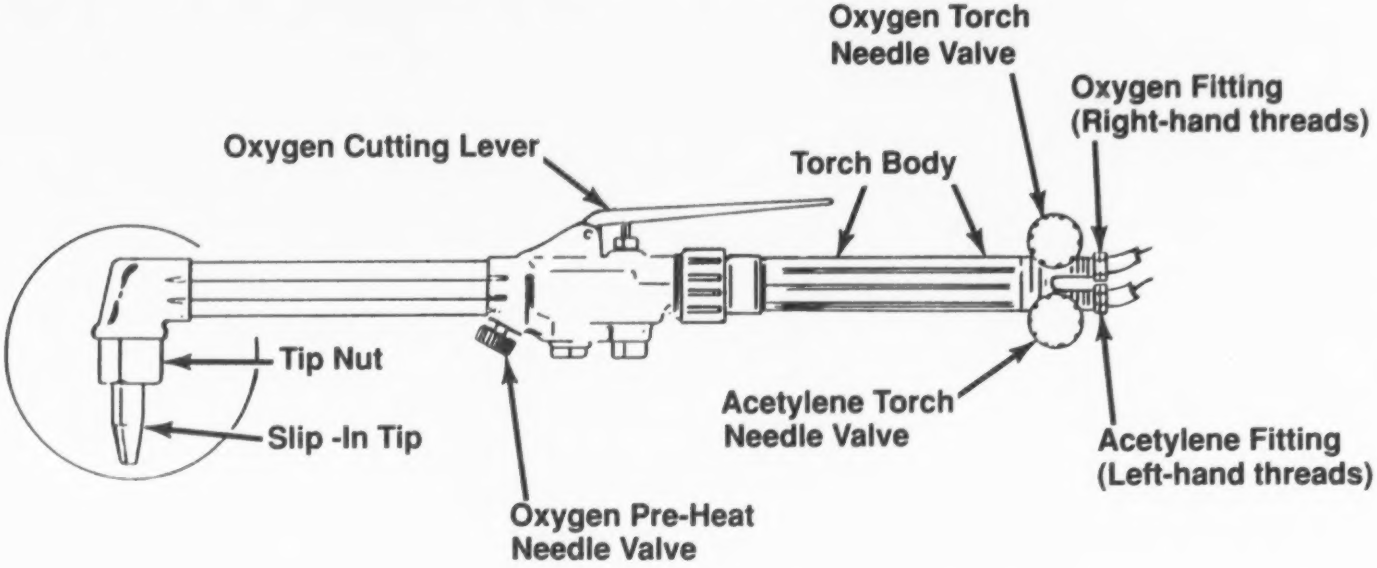
____

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

***Permission to duplicate this form is granted.**

Parts of a Cutting Torch


Oxygen Torch Needle Valve
Oxygen Fitting (Right-hand threads)
Oxygen Cutting Lever
Torch Body
Tip Nut
Slip -In Tip
Acetylene Torch Needle Valve
Acetylene Fitting (Left-hand threads)
Oxygen Pre-Heat Needle Valve

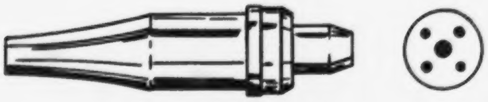
Oxyacetylene Welding and Cutting, Second Edition, Unit 2
Teacher Page 19

Cutting Tip Data Chart

Metal Thickness	Tip Size	Regulator Pressure PSI		
		Acetylene	Other Fuel Gases	Oxygen
⅛″	000	6	10-11	23
3/16″	00	6	10-11	23
¼″	0	7	10-11	33
⅜″	0	7	10-11	40
½″	1	7	10-11	40
⅝″	1	7	10-11	45
¾″	2	7	10-11	40
1″	2	7	10-11	45
1¼″	2	7	10-11	55
1½″	3	8	10-11	50
2″	3	8	10-11	55
2½″	4	8	10-11	45
3″	4	8	10-11	50
4″	4	8		60
5″	5	9		60
6″	5	9		70
8″	5	9		80

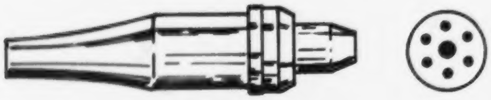
Courtesy Smith Welding Equipment

Typical Cutting Tips and Orifices



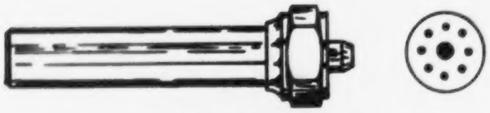
Acetylene

Light Preheat, Light Cutting



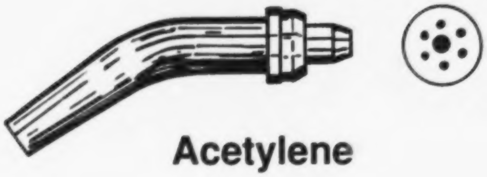
Acetylene

Medium Preheat, Light Cutting



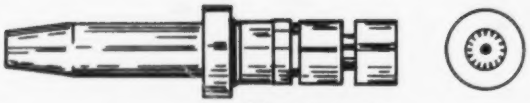
Acetylene

Heavy Preheat, Heavy Cutting



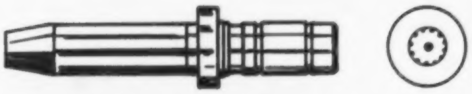
Acetylene

Medium Preheat, Gouging



Propane

General Purpose



Natural Gas (Methane)

General Purpose

Oxyacetylene Cutting
Unit 2

Information Sheet

1. **Terms and definitions**

    a. **Drag line** — A condition where the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

    b. **Kerf** — The width of the cut produced during a cutting process

    c. **Slag** — A nonmetallic residue left after oxyacetylene cutting

    d. **Soapstone** — A talc-based marking pencil that has a soapy feel and is used for marking lines on workpieces

    e. **Wraparound** — A pliable strip of durable gasket material with edges that are perfectly straight and parallel so that it provides a guide for marking a straight line around the circumference of a pipe

2. **Advantages of oxyacetylene cutting**

    a. Oxyacetylene cutting units are readily portable and can be taken to the work, as opposed to having to bring the work to the cutting equipment.

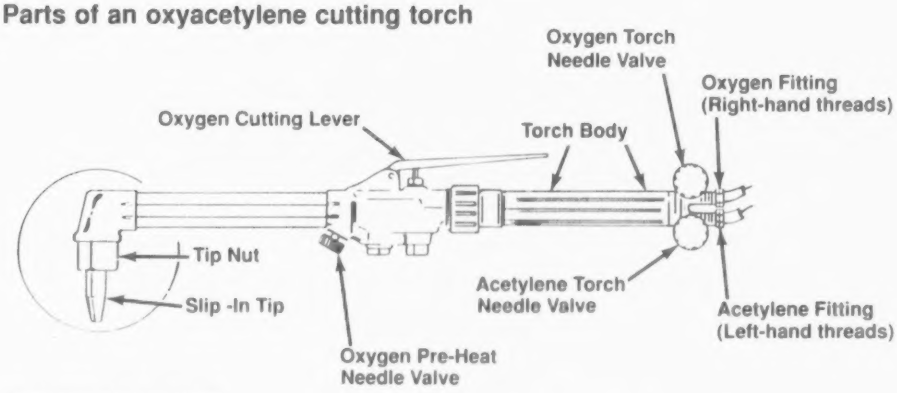
    b. Oxyacetylene cutting equipment is relatively inexpensive when compared to the cost of other cutting procedures.

    c. Oxyacetylene cutting, when properly executed, delivers a high-quality cut on ferrous materials.

    d. Oxyacetylene cutting is often done manually but can be adapted to automatic processes.

Information Sheet

3. Parts of an oxyacetylene cutting torch


Oxygen Torch Needle Valve
Oxygen Fitting (Right-hand threads)
Oxygen Cutting Lever
Torch Body
Tip Nut
Slip -In Tip
Acetylene Torch Needle Valve
Acetylene Fitting (Left-hand threads)
Oxygen Pre-Heat Needle Valve

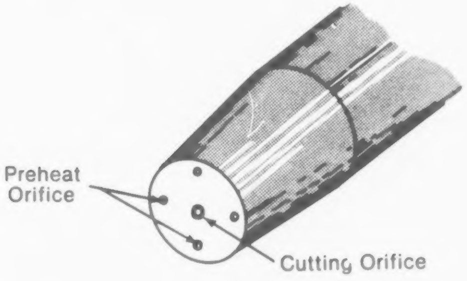
4. Cutting tip design

a. Cutting tips can be quickly changed so cutting can quickly be adapted to different thicknesses of metal.

b. Cutting tips are designed with two or more preheat orifices and one oxygen orifice.

c. Preheat orifices provide a mixture of oxygen and acetylene for preheating a base metal.

d. The single oxygen orifice directs a pressurized stream of pure oxygen onto the heated metal to accelerate the oxidation process that blows the metal away and completes the cut.


Preheat Orifice
Cutting Orifice

e. Oxyacetylene cutting tips have to be tightened with a wrench.

Information Sheet

5. **Guidelines for cutting tip selection**

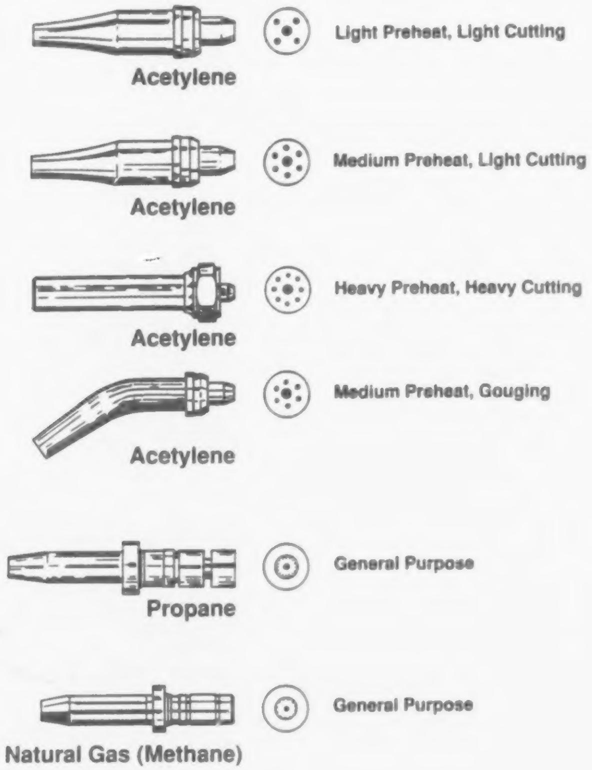
   a. Determine the thickness of material to be cut and use the size tip recommended by the manufacturer.

   b. Tip size has a direct relation to gas regulator pressures and pressures recommended by the manufacturer should always be followed.

   c. Tip size affects rate of cutting speed and should be based on the needs of the cutting application.

   d. Tip orifice should be compatible with the nature of work and fuel gas used.

Typical Cutting Tips and Orifices


Acetylene
Light Preheat, Light Cutting
Acetylene
Medium Preheat, Light Cutting
Acetylene
Heavy Preheat, Heavy Cutting
Acetylene
Medium Preheat, Gouging
Propane
General Purpose
Natural Gas (Methane)
General Purpose

Information Sheet

6. **Guidelines for cleaning cutting tips**

   a. Because cutting tips inevitably pick up carbon and/or slag, clean cutting tips often.

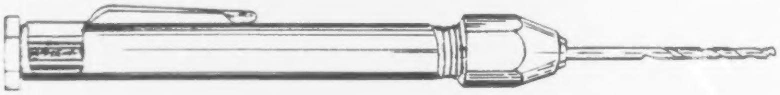
   b. Always select a cleaning probe smaller than the orifice to be cleaned; never force a cleaning probe into an orifice.

   c. Take special care not to break the cleaning probe off inside an orifice.

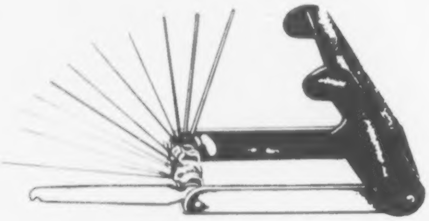
   d. Be careful with the seating edges on cutting tips because some of them can be easily damaged.

7. **Tip cleaning tools and their uses**

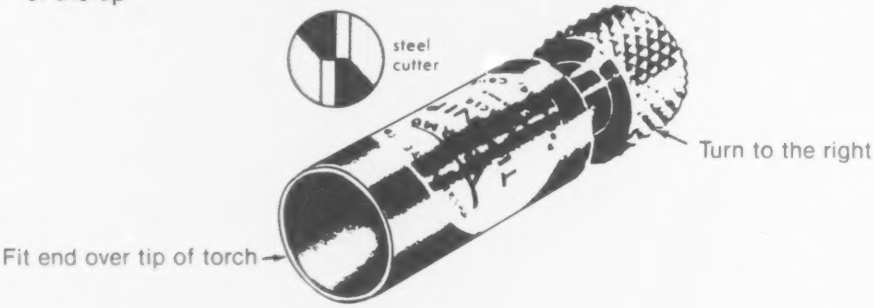
   a. Tip drill — A miniature drill; used for cleaning and reconditioning orifices



   b. Tip cleaner — A device with a series of small file-like probes that are gauged to match specific orifice openings; used to remove carbon build-up inside the tip



   c. Tip nip — A circular-shaped device with small steel cutting blades inset so it can be placed over the entire end of the tip; used to both clean and restore the face of the tip



Information Sheet

8. Rules for tip use

a. Never use a tip as a hammer to chip slag off a cut.

b. Never try to clean a tip by rubbing it on fire brick or against anything not designed for tip cleaning.

c. Never use an oily or greasy wrench to tighten a cutting tip, and never use an oily rag to clean dirt from a tip.

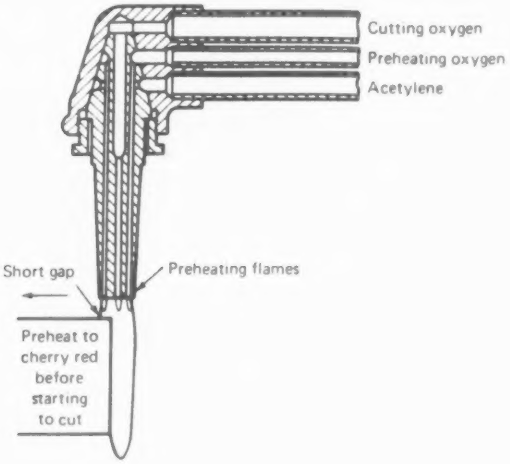
9. Guidelines for metal preparation for oxyacetylene cutting

a. For all critical cutting that requires following layout lines, burn metal free of oil and grease.

b. Remove scale and rust with a wire brush.

10. Steps for properly starting a cut

a. Place the cutting tip so that the preheat flame is half on the metal and half off the edge of the metal, and the tip is perpendicular to the metal surface.



Courtesy American Welding Society

b. Place the tips of the preheat inner cones as close as possible to the metal without touching it.

c. Preheat the starting point until the metal is cherry red, then depress the oxygen cutting lever.

d. When cutting starts, tilt the cutting tip slightly in the direction of the cut and move the tip at a constant speed along the cut line.

Note: Torch angle will vary with the thickness of the metal being cut.

Information Sheet

11. Techniques for restarting a cut

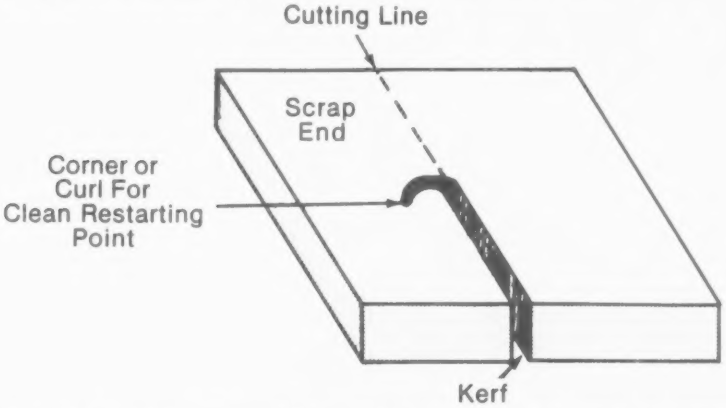
a. Anytime cutting stops, release the oxygen cutting lever immediately, preheat the restarting point at the edge only, and start again as if beginning a cut.

b. Blowholes are the biggest problem with restarting a cut, and blowholes can be avoided if you:

(1) Stop torch travel before releasing the oxygen cutting lever.

Note: This is especially effective on long cuts that you know will have one or more restarting points.

(2) Move the torch into the scrap area beyond the cutting line to form a corner or a curl about ¼" long so the cut can be restarted in the scrap area and moved cleanly back to the original cutting line.



Note: This technique permits you to reposition the torch at comfortable intervals on long cuts, and when properly executed, the re-entry point along the cut line can hardly be detected.

c. Avoid cutting across slag when restarting because the slag will fly in all directions and create a hazard.

12. Techniques for cutting straight lines

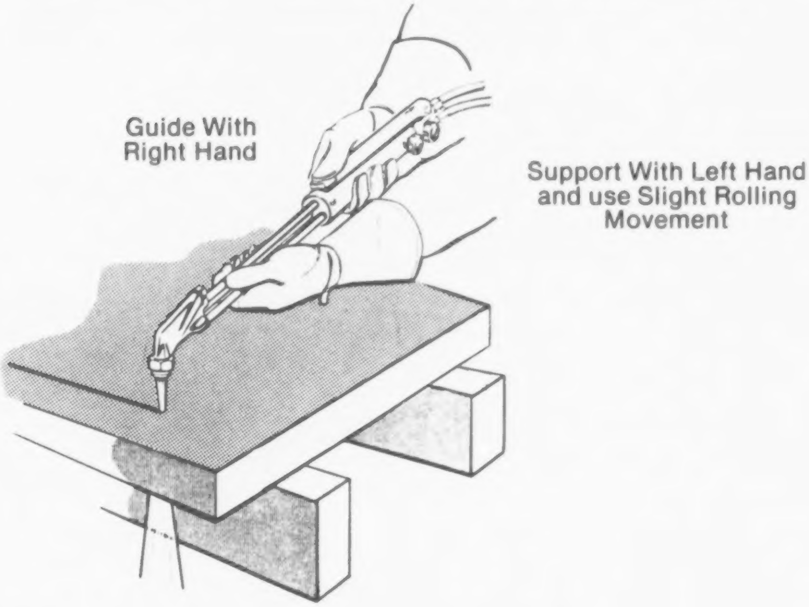
a. Hold the torch in your right hand with your thumb on the cutting lever and the torch centered in front of your body.

b. Support the torch in your left hand with a relaxed grip that will permit the torch to be turned.

Information Sheet

c. As you move the torch along the cutting line, roll your left hand slightly to the left from time to time to make the adjustment required to keep the cutting flame straight along the line.

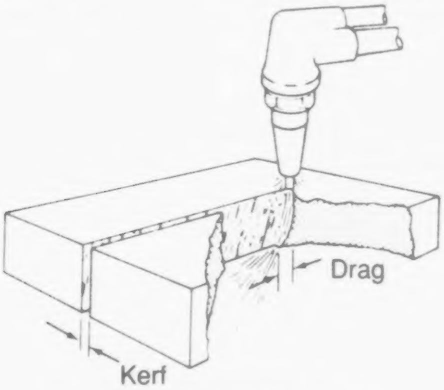
Note: The slight rolling technique with the left hand is the secret to good, straight cuts, so make some dry runs until you get the feel of it.


Guide With Right Hand
Support With Left Hand and use Slight Rolling Movement

Courtesy Modern Engineering Company, Inc.

13. Techniques for controlling kerf and drag

a. Good oxyacetylene cutting should produce a clean kerf with minimum drag, and this requires proper tip selection, proper travel speed, and proper fuel gas pressures.

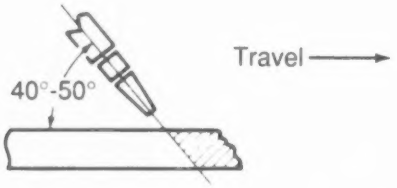


Courtesy American Welding Society

Information Sheet

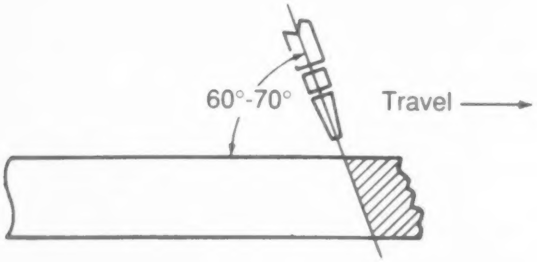
b. The thickness of the metal being cut should dictate tip selection and fuel gas pressures, but cutting torch angle is also important for a clean cut.

   (1) For plate thickness ¼" and less, the torch should be angled about 40°-50° from the base metal surface.



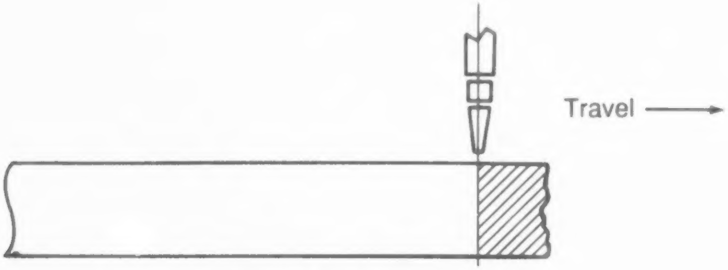
Courtesy American Welding Society

   (2) For plate thickness ¼"-½", the torch should be angled about 60°-70° from the base metal surface.



Courtesy American Welding Society

   (3) For plate thickness over ½", the torch should be held perpendicular to the plate.



Courtesy American Welding Society

Information Sheet

14. Elements of a good cut

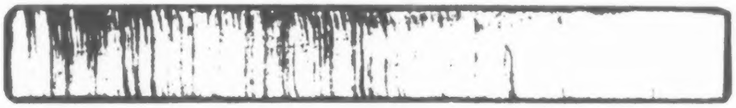
a. The edge is square.

b. Drag lines are vertical and clean.

c. There is no adhering slag at the bottom edge of the cut.

Note: The following illustration shows a proper cut made in a steel plate approximately 1″ thick and should be referenced for comparison with the cuts shown in objective 15.

Example:



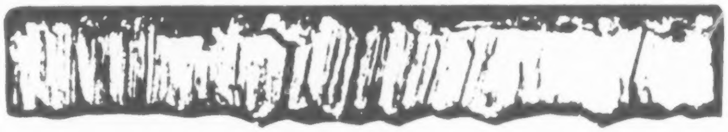
15. Characteristics of poor cuts and their causes

a. Bad gouging at bottom of cut—Preheat flame was not hot enough, resulting in too slow a cutting speed

Example:

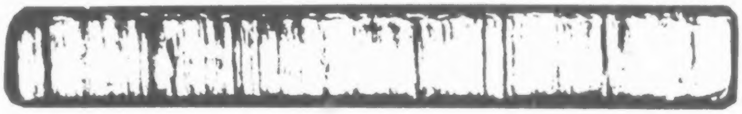
b. Top surface melted over, irregular cut edge, and excessive adhering slag—Preheat flame was too hot

Example:



c. Top edge melted over—Oxygen pressure too low, resulting in too slow a cutting speed

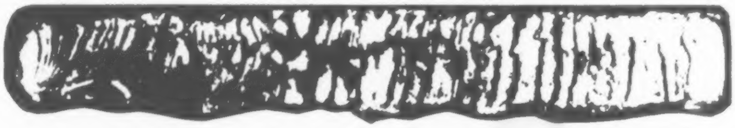
Example:



Information Sheet

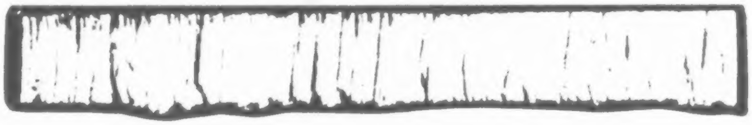
d. Loss of cut control by operator—Oxygen pressure was too high and the tip size was too small

Example:



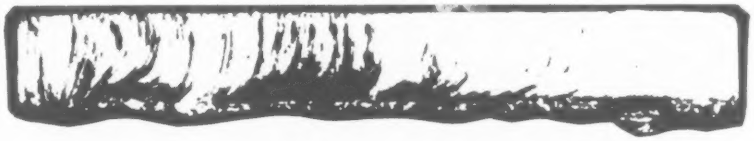
e. Drag line irregularities—Cutting speed was too slow

Example:



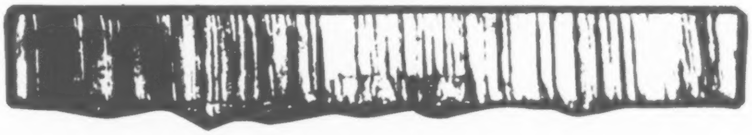
f. Pronounced break in the drag line with irregular cut edge—Cutting speed was too fast

Example:



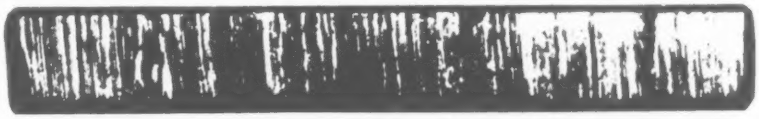
g. Cut edge wavy and irregular—Torch travel was unsteady

Example:



h. Bad gouges at restarting point—Cut was lost and improperly restarted

Example:



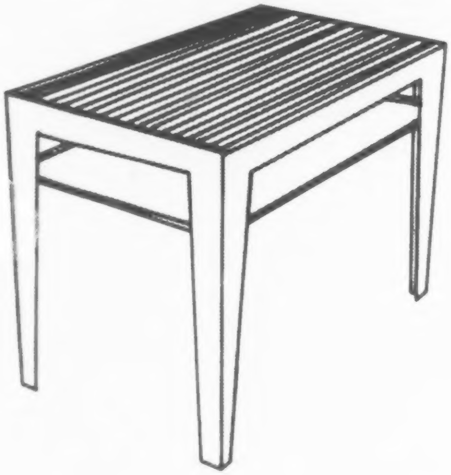
Information Sheet

16. Safety requirements for oxyacetylene cutting

a. When oxyacetylene cutting, follow all the rules that apply to safe oxyacetylene welding.

b. Because higher oxygen pressure creates showering sparks, use shielding screens to protect nearby areas.

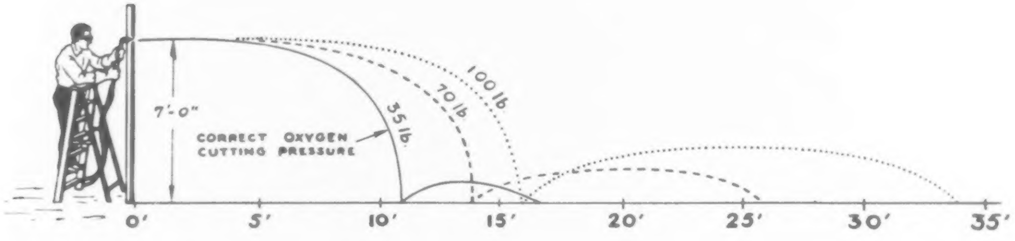
c. Perform cutting on a proper cutting table that provides a work area with a grated surface that permits slag to drop through into a slag box.



d. Do not cut or weld on a masonry floor because moisture trapped in the masonry can heat rapidly and cause the floor to explode.

e. Because cutting sparks can fly long distances, move flammable material a safe distance from the cutting area.

f. Do not set oxygen pressure too high; too high a setting causes sparks to blow and wastes oxygen too.



Courtesy Modern Engineering Company, Inc.

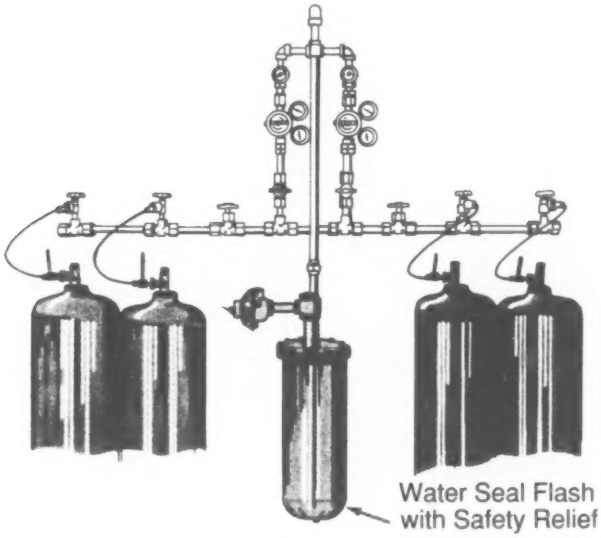
Information Sheet

g. Do not cut into any container because it may still contain the residue of highly explosive materials.

h. Keep cutting as far away from gas cylinders as hose length will permit.

17. Characteristics of manifold systems

a. Manifolds are systems that pipe oxygen and acetylene from two or more oxygen or acetylene tanks to provide a continuous gas supply when only one cylinder would be inadequate.



Water Seal Flash Arrestor with Safety Relief Valve (On Acetylene Side)

b. A manifold system should be large enough to supply volume for the largest size tip used.

c. A manifold should be equipped with a water seal flash arrester on the acetylene side.

d. Manifold systems save space when a number of work stations are required.

e. Manifold systems permit a school or shop to buy gases in quantity, reduce costs, and save money.

Information Sheet

18. Characteristics of track-type cutting machines

a. Track-type cutting machines require setup, alignment, and adjustment by an operator.

b. Track-type machines operate on tracks mostly designed for horizontal cutting, but some models have magnetic tracks that permit them to cut in vertical or overhead positions.

c. The carriage is motor-driven and speed is controlled by a governor.

d. Some track-type machines have provisions for mounting two or more torches.

e. Track-type machines are used mostly for making square or beveled cuts, but some machines can be modified with a radius rod to cut circles.

19. Characteristics of shape cutting machines

a. Machines vary in design from a single wheel to three wheels with attachments for cutting straight lines, bevels, circles, and irregular shapes.

b. Machines are adjustable to many steel forms including rod and pipe, and can be used to cut horizontally or vertically.

Information Sheet

c. Machines are controlled by operators who control the speed and direction of a cutting torch that is centered in front of or beside a drive mechanism.

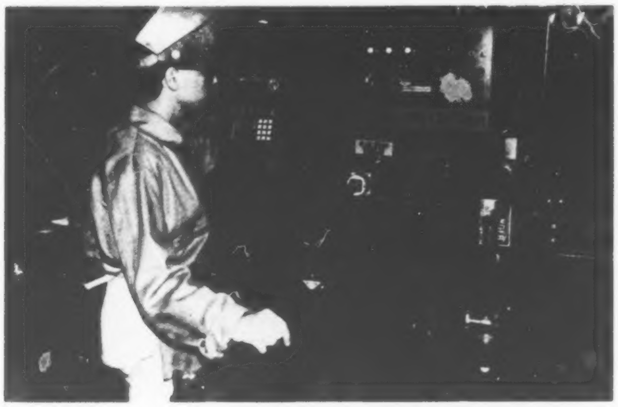
20. Characteristics of automated cutting machines

a. Automated cutting machines are usually designed for a specific job where the cutting of multiple identical shapes contributes to high productivity.

b. Automated machines function as tracing devices that use a photocell or an electric eye to trace a pattern, or use magnetic devices to trace a metal template.

c. These machines usually have a panel or terminal to give an operator precise control over gas torch operations.

d. These machines are sometimes programmed numerically with punched tape fed into a master control unit, but they are sometimes controlled with solid-state digital devices such as a computer or a programmable logic controller.



21. Characteristics of pipe beveling machines

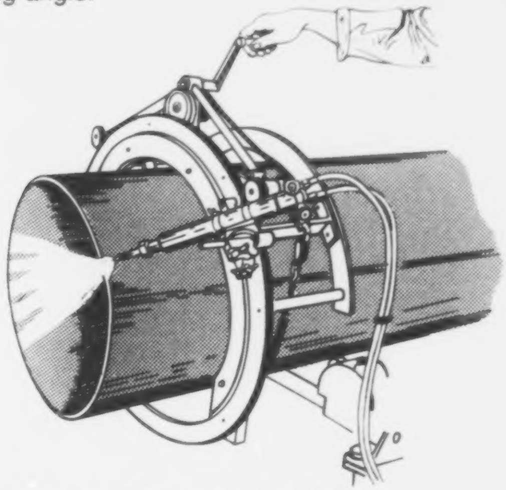
a. Pipe beveling machines are designed specifically for cutting beveled angles, T's and Y's, and other connecting shapes for pipe.

b. Beveling machines may be manually operated or motorized.

c. The basic machine design is a split horseshoe that fits the outside contour of the pipe and is then clamped into position for cutting.

Information Sheet

d. Torch holders are designed with easy-to-read protractors for precise control of the cutting angle.



Courtesy H&M Pipe Beveling Machine Company, Inc.

e. A variation of the pipe beveling machine is a device that turns the pipe while the torch holder remains fixed instead of working around the pipe.

22. **Eye protection required for oxyacetylene cutting**

a. Wear safety glasses when cleaning or chipping slag from base metal.

b. Wear safety glasses and a face shield when grinding joints or bevels.

c. Wear welding and cutting goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from intense light rays.

Type of Cutting	Metal Thickness	Shade #
Light	Up to 1″	3 or 4
Medium	1″-6″	4 or 5
Heavy	6″ +	5 or 6

Oxyacetylene Cutting
Unit 2

Job Sheet 1—Set Up, Adjust Cutting Flame, and Shut Down Oxyacetylene Cutting Equipment

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Neutral flame adjustment	______
Cutting flame adjustment	______
Equipment shut down and safety	______

A. Tools and materials

Oxygen cylinder
Acetylene cylinder
Oxygen regulator
Acetylene regulator
Hoses and check valves
Wrench
Cylinder holder
Torch body with tips
Leak detector
Cutting goggles and safety glasses

B. Procedure

☐ 1. Fasten cylinders in a vertical position.

☐ 2. Remove caps from cylinders.

☐ 3. Crack valves of each cylinder momentarily, then close valves.

☐ 4. Connect oxygen regulator to oxygen cylinder.

☐ 5. Turn the adjusting screw on the oxygen regulator counterclockwise until tension on the spring is released.

☐ 6. Connect the acetylene regulator to the acetylene cylinder.

☐ 7. Turn the adjusting screw on the acetylene regulator counterclockwise until tension on the spring is released.

Job Sheet 1

☐ 8. Connect the oxygen hose to the oxygen check valve, and then connect the check valve to the oxygen regulator.

☐ 9. Connect the acetylene hose to the acetylene check valve, and then connect the check valve to the acetylene regulator.

Note: Check valves can be installed between hoses and torch body.

☐ 10. Connect the oxygen and acetylene hoses to the torch body, and then close both needle valves on the torch body.

☐ 11. Select tip size according to the thickness of metal to be cut, and the tip manufacturer's recommendations; attach tip to cutting attachment.

☐ 12. Attach the cutting attachment to the torch body.

☐ 13. Double check to make sure the oxygen and acetylene needle valves and the oxygen preheat valve are all closed.

☐ 14. Turn the oxygen cylinder valve slowly wide open.

☐ 15. Turn the acetylene cylinder valve slowly one half to three quarters of a turn.

☐ 16. Turn the adjusting screw on the oxygen regulator clockwise until the regulator indicates the correct working pressure.

☐ 17. Turn the adjusting screw on the acetylene regulator clockwise until the regulator indicates the correct working pressure.

☐ 18. Use a safe leak detector to test all connections for leaks.

☐ 19. Have your instructor check your work.

☐ 20. Open the oxygen needle valve on the torch to a full open position and then open the acetylene needle valve half a turn.

☐ 21. Light the torch with a flint lighter.

☐ 22. Open oxygen preheat valve slowly and adjust to a neutral flame and readjust acetylene needle valve if necessary.

☐ 23. Depress the oxygen cutting lever and check to see that a neutral flame is still present.

☐ 24. Keep the oxygen cutting lever depressed and adjust the oxygen preheat valve until you have a neutral flame.

Job Sheet 1

☐ 25. Have your instructor check the cutting flame.

☐ 26. Release oxygen cutting lever and begin shut down.

☐ 27. Close the oxygen preheat needle valve on the cutting attachment.

☐ 28. Close the acetylene needle valve on the torch body.

☐ 29. Close the oxygen valve on the cylinder.

☐ 30. Close the acetylene valve on the cylinder.

☐ 31. Press the oxygen cutting lever to release pressure from the oxygen regulator and hose, and then release the cutting lever.

☐ 32. Turn the oxygen regulator adjustment screw counterclockwise

☐ 33. Close the oxygen needle valve on the torch body.

☐ 34. Open the acetylene needle valve on the torch body to release pressure from the acetylene regulator and hose, and then close the acetylene needle valve.

☐ 35. Turn the acetylene regulator adjustment screw counterclockwise to release spring tension.

☐ 36. Have your instructor check your shut down.

☐ 37. Check in tools and materials as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Cutting
Unit 2

Job Sheet 2—Make 90° Cuts and Restart a Cut on Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Cutting flame adjustment	______
Torch angle and torch manipulation	______
Quality of 90° cuts	______
Preheat for restart	______
Quality of restart	______
Equipment shut down and safety	______

A. Tools and materials

- Cutting outfit with tip assembly
- Mild steel plate as selected by instructor
- Soapstone with a sharp point or edge
- Straightedge
- Gloves
- Welding goggles and safety glasses
- Pliers
- Protective clothing
- Flint lighter
- Welding or cutting table
- Slag box
- Can of water
- Cutting tip

B. Procedure

☐ 1. Mark four parallel lines 2" apart on plate to be cut.

☐ 2. Adjust oxygen regulator.

☐ 3. Adjust acetylene regulator.

☐ 4. Place plate to be cut on cutting table.

Job Sheet 2

☐ 5. Light torch.

☐ 6. Adjust to neutral flame.

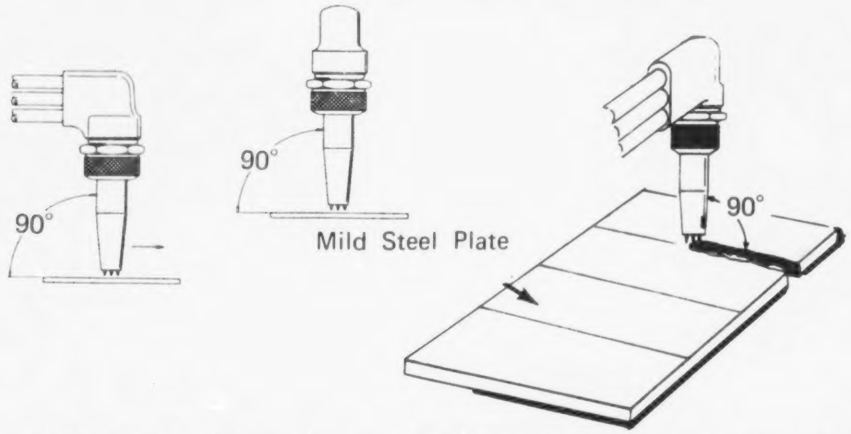
☐ 7. Assume comfortable position.

☐ 8. Place hoses behind operator.

☐ 9. Maneuver torch with both hands.

☐ 10. Hold preheat flame with tip of inner cone $^1/_{16}$" to $^1/_8$" above top of plate at right edge until reddish-yellow spot appears.

☐ 11. Depress the oxygen cutting lever, and move from right to left across the plate (for left-handed operators, go from left to right).



☐ 12. Hold the tip at right angles to work while maintaining correct inner cone distance.

☐ 13. Make 90° cuts until you have developed the proper procedure.

☐ 14. Release the oxygen cutting lever, and turn the torch off.

☐ 15. Use pliers to dip the plates in water to cool them.

☐ 16. Have your instructor check your 90° cuts.

☐ 17. Secure one of the plates and start a cut, stopping approximately midway through the cut.

☐ 18. Release the cutting lever.

☐ 19. Preheat the edge where the cutting stopped.

Job Sheet 2

☐ 20. Depress the oxygen cutting lever slowly and restart the cut.

☐ 21. Complete the cut and shut down equipment as previously outlined.

☐ 22. Have your instructor check your restart.

☐ 23. Check in tools and materials as directed by your instructor.

Evaluator's comments: ____

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Oxyacetylene Cutting
Unit 2

Job Sheet 3—Make a Flame-Beveled Cut on Mild Steel Plate

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Neutral flame adjustment	______
Torch and cutting flame manipulation	______
Quality of beveled cuts	______

A. Tools and materials

Cutting outfit with tip assembly
Mild steel plate as selected by instructor
Soapstone with a sharp point or edge
Straightedge
Gloves
Welding goggles and safety glasses
Pliers
Protective clothing
Flint lighter
Welding or cutting table
Slag box
Can of water
Cutting tip

B. Procedure

☐ 1. Place mild steel plate on cutting table.

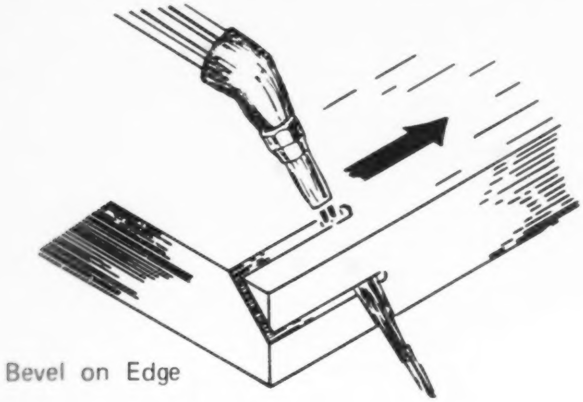
☐ 2. Light and adjust cutting torch to a neutral flame.

Note: Oxygen cutting pressures are greater for bevel cuts than 90° cuts.

☐ 3. Place hoses behind operator.

Job Sheet 3

☐ 4. Hold torch with both hands at desired angle to metal as shown.



☐ 5. Hold preheat flame with tip of inner cone (neutral flame) 1/16" to 1/8" above top of plate until red spot appears.

☐ 6. Depress the oxygen cutting lever and proceed across plate with very consistent movement, being careful to maintain constant travel speed, torch angle, and flame-to-work distance.

☐ 7. Practice until you have developed the proper procedure.

☐ 8. Have your instructor check your work.

☐ 9. Check in tools and materials as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Cutting
Unit 2

Job Sheet 4—Cut Holes in Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Neutral flame adjustment	______
Flame and torch manipulation to pierce plate	______
Flame and torch manipulation to cut circles	______
Quality of cut holes	______

A. Tools and materials

Cutting outfit with tip assembly
Mild steel plate as selected by instructor
Soapstone with a sharp point or edge
Straightedge
Gloves
Welding goggles and safety glasses
Pliers
Protective clothing
Flint lighter
Welding or cutting table
Slag box
Can of water

B. Procedure

☐ 1. Draw two circles on metal with soapstone.

  a. 1″ in diameter, 1″ from edge

  b. ½″ in diameter, 1″ from edge

☐ 2. Adjust oxygen regulator.

☐ 3. Adjust acetylene regulator.

☐ 4. Place metal to be cut on cutting table.

☐ 5. Light torch.

Job Sheet 4

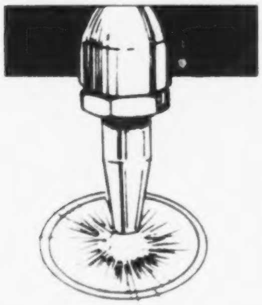
☐ 6. Adjust to neutral flame.

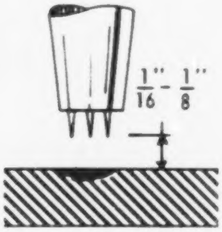
☐ 7. Assume comfortable position.

☐ 8. Place hoses behind operator.

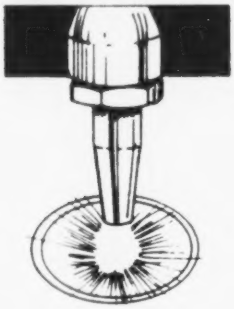
☐ 9. Maneuver torch with both hands.

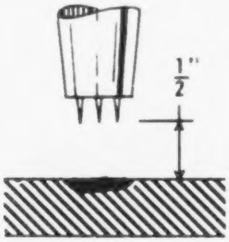
☐ 10. Hold tip of inner cone 1/16" to 1/8" above point to be cut until metal turns reddish-yellow.



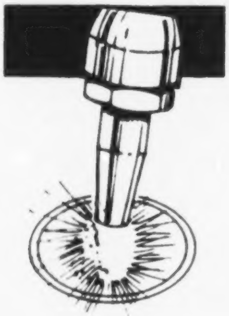


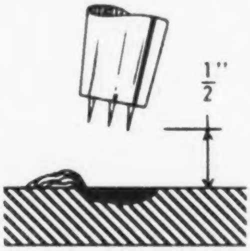
☐ 11. After the metal turns reddish-yellow, raise the inner cone approximately 1/2" above the point to be cut.





☐ 12. Tilt the torch 15° from the vertical position so that molten metal will be blown away from the operator.





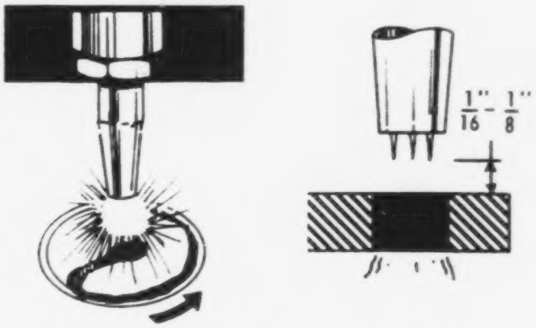
Job Sheet 4

☐ 13. Depress the oxygen cutting lever slowly, moving the torch backwards (to the operator's right, if right handed) until the flame pierces the plate.

☐ 14. Return the torch to the vertical position.

☐ 15. Lower the cutting tip until the tip of the inner cone is 1/16" to 1/8" above the plate.

☐ 16. Make the cut.



☐ 17. Cut just inside soapstone mark until circular cut is completed.

☐ 18. Repeat required steps until both holes are cut.

☐ 19. Use pliers to hold metal, and place metal in a can of water to cool.

☐ 20. Have your instructor check your work.

☐ 21. Check in tools and equipment and clean area.

Evaluator's comments: ____

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Oxyacetylene Cutting
Unit 2

Job Sheet 5—Lay Out a Pattern on Mild Steel Plate and Cut the Pattern to Specifications

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Plate marking and preparation	______
Neutral flame adjustment	______
Straight cuts to specifications	______
Beveled cuts to specifications	______

A. Tools and materials

Square and straightedge
Soapstone
Mild steel plate ¼″ to ½″ thick, 6″ square
Gloves
Welding goggles and safety glasses
Protective clothing
Pliers
Chipping hammer
Cutting equipment

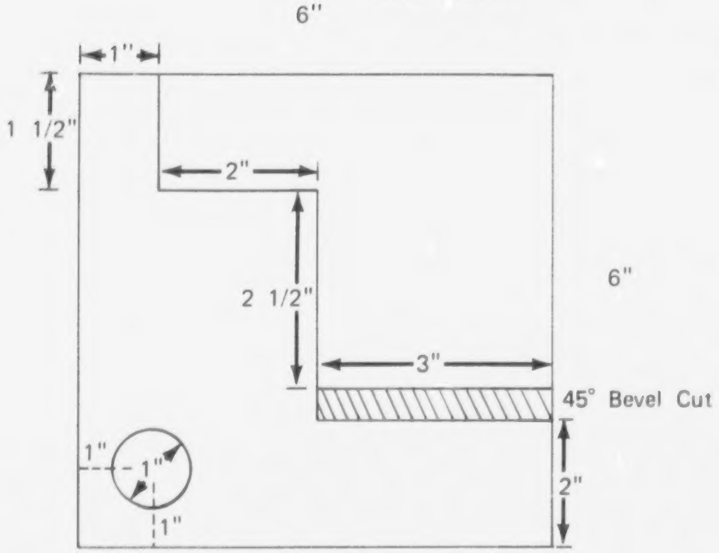
B. Procedure

☐ 1. Select starting point.

☐ 2. Measure distances and mark as indicated in following illustration.

☐ 3. Have instructor check your layout.

Job Sheet 5



☐ 4. Place plate on cutting table.

☐ 5. Set up cutting equipment and select appropriate tip for thickness of metal.

☐ 6. Light and adjust cutting torch flame.

☐ 7. Make straight cuts or bevel cuts as required to cut pattern to specifications.

☐ 8. Turn off torch.

☐ 9. Secure hot workpiece with pliers and quench to cool.

☐ 10. Have your instructor evaluate the slag on your cuts.

☐ 11. Chip slag and then inspect for proper torch angles, drag lines, and straightness.

☐ 12. Have your instructor check your work.

☐ 13. Shut down cutting equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

____

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Oxyacetylene Cutting
Unit 2

Job Sheet 6—Cut a Pipe Bevel by Hand

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Pipe positioning	______
Use of wraparound and marking	______
Neutral flame adjustment	______
Start of cut and torch manipulation	______
Pipe rotation	______
Final quality of bevel	______

A. Tools and materials

Oxyacetylene cutting unit with tip
Welding goggles and safety glasses
Welding gloves
Sparklighter
Pliers
Wraparound
Soapstone marker
Center punch (optional)
Pipe with at least 3/16" wall thickness
Tip wrench, if required
File
Wire brush

B. Procedure

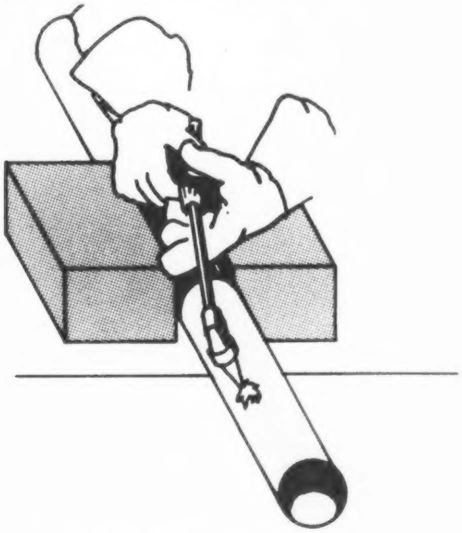
☐ 1. Inspect area to make sure it is free and clear of flammable materials and well ventilated, and note location of nearest fire extinguisher.

☐ 2. Select tip according to wall thickness of pipe, place on torch, and tighten with a wrench, according to manufacturer's recommendations.

Job Sheet 6

☐ 3. Place pipe on a suitable work surface and brace with pieces of fire brick so pipe can be rotated.

☐ 4. Place wraparound over pipe, make sure it overlaps to give a straight line, then mark the cutting line with soapstone.



☐ 5. Put on welding gloves and goggles.

☐ 6. Light and adjust torch to neutral flame.

☐ 7. Start preheating on the sidewall of the pipe at a point slightly down from the top of the pipe, about 10 or 11 o'clock.

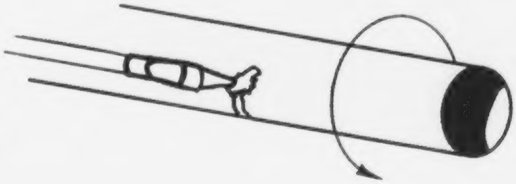
☐ 8. Angle the tip of the torch at the starting point so that it will make a cut of 35° through the pipe wall.

☐ 9. Move the torch down until the inner cone is about $\frac{1}{16}$″ to $\frac{1}{8}$″ from the pipe surface and heat a spot about the size of a dime until it turns a reddish-yellow.

☐ 10. After the metal turns a reddish-yellow, raise the inner cone to approximately ½″.

Job Sheet 6

☐ 11. Depress the oxygen cutting lever slowly, return to proper inner cone distance, cut for a few inches uphill, and then stop and rotate the pipe to the left.



☐ 12. Restart the cut by preheating as required, and keep making short cuts to the left while rotating the pipe until the cut is complete.

☐ 13. Turn torch off.

☐ 14. Cool pipe with water.

☐ 15. Use file to clean slag from inside the pipe and rough edges from the bevel, then clean with a wire brush.

☐ 16. Have your instructor check your work.

☐ 17. Continue cutting other bevels as directed by your instructor.

☐ 18. Shut down equipment, check in tools and materials, and clean area.

Evaluator's comments: ______________________________

____

____

Oxyacetylene Cutting
Unit 2

Job Sheet 7—Set Up and Cut a 30° Bevel with a Track-Type Torch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Workpiece preparation	______
Torch and tractor adjustments	______
Neutral flame adjustment	______
Tractor operation	______
Drag line and slag control	______
Quality of bevel cut	______

A. Tools and materials

Oxyacetylene cutting unit with tractor-type torch
Welding goggles and safety glasses
Welding gloves
Sparklighter
Pliers
Straightedge
Soapstone
Metal as selected by instructor
Tip wrench, if required

B. Procedure

☐ 1. Inspect area to make sure it is free and clear of flammable materials and well ventilated, and note location of nearest fire extinguisher.

☐ 2. Select tip according to thickness of metal, place on torch, and tighten with a wrench, according to manufacturer's recommendations.

☐ 3. Place material on work area and set up tractor and torch.

☐ 4. Adjust protractor on torch unit to an angle of 30°.

Job Sheet 7

☐ 5. Determine direction of travel, and determine travel speed according to tip size and thickness of metal, as recommended by manufacturer.

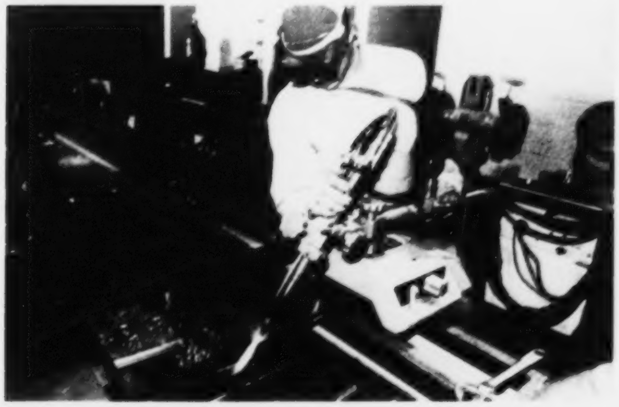
☐ 6. Put on cutting gloves and goggles.

☐ 7. Light and adjust torch to neutral flame.

Note: Lighting and adjusting a track-type torch is the same procedure used for a hand-held torch and the same safety rules should be observed.

☐ 8. Roll the tractor and torch to a point where the flame is at the edge of the metal, and adjust the flame so that the inner cone is 1/16" to 1/8" off the metal.

☐ 9. Hold the flame at the edge of the metal until the plate turns a reddish-yellow.



☐ 10. Open oxygen cutting valve and immediately engage the tractor drive motor.

☐ 11. Permit tractor and torch to run the entire length of the cut to complete the bevel.

Caution: NEVER leave an activated tractor-type machine unattended for even a moment.

☐ 12. Close oxygen cutting valve, disengage tractor drive motor, and turn motor off.

☐ 13. Turn torch off.

Job Sheet 7

☐ 14. Cool the workpiece with water.

☐ 15. Inspect bevel for correctness of angle, drag line, and slag accumulation.

☐ 16. Have your instructor check your work and continue to practice cutting bevels as directed.

> **Caution: When you remove the workpiece for inspection, use pliers.**

☐ 17. Clean area and check in tools and materials

Evaluator's comments: ____________________

____

____

Oxyacetylene Braze Welding and Surfacing
Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to weld a stringer bead with bronze rod on a steel plate, braze weld a butt joint in the flat position and a lap joint in the horizontal position, and repair a worn tool with hardfacing. The student will demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to oxyacetylene braze welding and surfacing with their correct definitions.
2. Differentiate between the definitions of *fusion welding* and *braze welding*.
3. Differentiate between the definitions of *brazing* and *braze welding*.
4. Select true statements about the advantages of braze welding.
5. Select true statements about the limitations of braze welding.
6. Complete statements about precoating in braze welding.
7. Select true statements about the purposes of flux.
8. Complete statements about the characteristics of filler rods for braze welding.
9. Complete statements about important factors in successful braze welding.
10. Select true statements about techniques used in preparing joints for braze welding.
11. Complete statements about techniques used to remove oxides in preparating joints for braze welding.

Objective Sheet

12. Complete statements about techniques used for braze welding steel and cast iron.

13. Match braze welding problems with their causes.

14. Differentiate between the definitions *surfacing* and *hardfacing.*

15. Select true statements about the advantages of bronze surfacing.

16. Complete statements about limitations of bronze welding.

17. Differentiate between methods of preparing new and cast iron surfaces for bronze surfacing.

18. Select true statements about guidelines for bronze surfacing.

19. Select true statements about guidelines for hardfacing applications.

20. Match types of hardfacing alloys with their definitions.

21. Complete statements about hardfacing powders.

22. Complete statements about the advantages of hardfacing with an oxyacetylene torch.

23. Complete statements about guidelines for preparing surfaces for hardfacing.

24. Identify requirements for machining surfaces to be hardfaced.

25. Select true statements about preheating and cooling requirements for hardfacing.

26. Complete statements about techniques used for oxyacetylene hardfacing.

27. Select true statements about techniques for making a second pass when oxyacetylene hardfacing.

28. Complete statements about safety precautions used for hardfacing.

29. Weld a stringer bead with a bronze rod on steel plate. (Job Sheet 1)

30. Braze weld a square groove butt joint in the flat position. (Job Sheet 2)

31. Braze weld a lap joint in the horizontal position. (Job Sheet 3)

32. Repair a worn tool with hardfacing. (Job Sheet 4)

Oxyacetylene Braze Welding and Surfacing
Unit 3

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make a transparency of the "Metals Preheating Chart" that appears only in this teacher edition of the text. The transparency is designed to help reinforce Objective 24, but you may also want to use the chart with other objectives related to preheating.

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide student with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss job sheets. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

Suggested Activities

15. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD guidelines have been adapted by MAVCC.

1. Talk to students about the added job opportunities available for truly multi-talented welders. Braze welding, bronze surfacing, and hardfacing are full time jobs for some welders, but certain jobs demand these skills on an "as needed" basis, and the welder with skills versatility always gets the better job.

2. Gather a sufficient number of worn tools for students to use with Job Sheet 4. Plowshares, are ideal. Pay particular attention to the type of wear the worn tools were subjected to and impress upon students that the type of wear a tool or part is subjected to is a determining factor in selecting filler metal and in preparing the workpiece. (**Foundation skills**)

3. Continue to stress eye safety and the need for students to wear safety glasses in the welding area even when they're not welding or cutting.

Resources Used in Developing This Unit

1. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.

2. O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

3. *Welding Fabrication & Data Book 1988/89.* Cleveland, OH: Penton Publishing, Inc., 1988.

Suggested Activities

Suggested Supplemental Resources

1. FIL-7 "Hardfacing." 16mm film covers flame adjustment and special techniques for thin-edged parts. Available from:

   Films, Inc.
   5544 North Ravenswood Avenue
   Chicago, IL 60640
   800-323-4222 ext. 43 or 312-878-2600 ext. 43

2. ITC-1 "Brazing and Braze Welding." Videocassette covers safety, filler metal, fluxes, joints, and procedures. Available from:

   Industrial Training Corporation
   13515 Dulles Technology Drive
   Herndon, VA 22071-3416
   800-638-3757 or 703-471-1414

3. MEC-28 "Oxyacetylene Hardfacing Techniques for Agriculture." Filmstrips with cassettes or videocassette covers processes and techniques. Available from:

   Meridian Education Corporation
   Library Filmstrip Center
   236 East Front Street
   Bloomington, IL 61701
   309-827-5455

4. A variety of brochures and guidebooks dedicated to all areas of hardfacing. Available from:

   The Stoody Company
   16425 Gale Avenue
   Industry, CA 91749
   818-968-0717

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher guide or student manual. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Oxyacetylene Braze Welding and Surfacing
Unit 3

Answers to Written Test

1. a. 3
   b. 5
   c. 1
   d. 4
   e. 7
   f. 2
   g. 6

2. a. F
   b. B

3. a. B
   b. W

4. b, d, e, f

5. a, b, d, e

6. a. Brass and bronze
   b. Cleaned
   c. Neutral to slightly reducing
   d. Good brazing flux
   e. Overheating

7. a, b, c, e, f, g

8. a. 60 percent copper and 40 percent zinc
      (1) Tensile
      (2) Ductility
   b. Silicon
      (1) Weld metal
      (2) Fume
      (3) Molten metal
      (4) Wear resistance
   c. Emery cloth

9. a. 3
   b. 2
   c. 1

10. a, d, e

11. a. Wire brush or portable grinder; flux
    b. Both chemical and mechanical methods

Answers to Written Test

12. a. 1
    b. 2
    c. 2
    d. 2
    e. 1

13. a. 2
    b. 1

14. a. B
    b. H

15. a, c

16. a. Superheated steam engine pistons
    b. Piston rods

17. b

18. b, c, e, f, g

19. a, b, c

20. a. 2
    b. 4
    c. 1
    d. 3

21. a. Thin
    b. Smooth
    c. Wetting
    d. General
    e. Reducing

22. a. 3
    b. 2

23. a. Any foreign substance
    b. Specific sections of a part
    c. Round off

24. a. 1
    b. 2
    c. 1

25. a, b, c, d

Answers to Written Test

26. a. 3
    b. 3
    c. 2

27. a, c, d, f

28. a. 2
    b. 3
    c. 2

Oxyacetylene Braze Welding and Surfacing
Unit 3

Written Test

Name ________________________________ Score ______________

1. Match the terms on the right with their correct definitions.

_____a. A flame with more acetylene than a neutral flame

_____b. A material used to hinder or prevent the formation of oxide and other undesirable substances in molten metal and on solid metal surface, and to dissolve or otherwise facilitate the removal of such substances

_____c. A surfacing variation in which surfacing material is deposited to reduce wear

_____d. Mechanically grinding or milling surfaces, edges, and corners to precise dimensions of a workpiece to be welded; finishing a workpiece after welding

_____e. The chemical reaction of a metal with oxygen in the air in a process that promotes contamination of metal surfaces and eventually leads to rust

_____f. A flame with more oxygen than a neutral flame

_____g. Coating the base metal in a joint by dipping, electroplating, or other means prior to soldering or brazing

1. Hardfacing
2. Oxidizing flame
3. Carburizing flame
4. Machining
5. Flux
6. Precoating
7. Oxidation

Written Test

2. Differentiate between the definitions of *fusion welding* and *braze welding*. Place an "F" beside the definition of fusion welding and a "B" beside the definition of braze welding.

_______a. The filler rod has a melting point approximately the same as the melting point of the base metal, and both the filler metal and the base metal are melted and fused together.

_______b. The filler rod has a melting point below the melting point of the base metal, the base metal is never melted, and the weld is formed as a result of gravity pull resulting from weld design.

3. Differentiate between the definitions of *brazing* and *braze welding*. Place an "B" beside the definition for brazing and a "W" beside the definition of braze welding.

_______a. The filler metal must have a melting point above 840°F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction.

_______b. The filler metal must have a melting point above 840°F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction.

4. Select true statements about the advantages of braze welding. Place an "X" beside each true statement.

_______a. Braze welding is almost as fast as fusion welding because the heat input required is less.

_______b. Braze welding saves time and reduces fuel gas consumption.

_______c. Braze welding eliminates preheating requirements.

_______d. The reduction of heat input in braze welding has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools.

_______e. Because of a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal.

_______f. Braze welding can be used to join dissimilar metals that cannot be fusion welded.

Written Test

5. Select true statements about the limitations of braze welding. Place an "X" beside each true statement.

______a. In braze welding, the weld color cannot match the base metal.

______b. Because there are no filler rods for special applications, braze welding cannot be used on metal and joints where high stress is a factor.

______c. A braze weld will lose its strength at temperatures above 300°F.

______d. A braze weld may have corrosion-resistant properties different from those of the base metal.

______e. The strength of a braze weld is limited to the strength of the filler metal.

6. Complete statements about precoating in braze welding. Circle the information that best completes each statement.

a. Braze welding is based on the principle that (brass and bronze) (tin and zinc) when raised to the proper temperature will melt and form a smooth precoating film on the surface of a properly prepared and heated joint.

b. Precoating cannot be properly accomplished unless the joint has been thoroughly (cleaned) (heated) and properly prepared.

c. Good precoating requires a (neutral to slightly reducing) (neutral to slightly carburizing) flame.

d. Precoating requires a (steady hand) (good brazing flux).

e. Improper precoating action is almost always caused by (underheating) (overheating) the base metal.

7. Select true statements about the purposes of flux. Place an "X" beside each true statement.

______a. Flux chemically cleans the base metal.

______b. Flux prevents oxidation of the filler metal.

______c. Flux floats and removes the oxides already present.

______d. Flux slows the flow of the filler metal.

______e. Flux increases the ability of the filler metal to adhere to the base metal.

______f. Flux brings the filler metal into immediate contact with the metals being joined.

______g. Flux permits the filler metal to penetrate the pores of the base metal.

Written Test

8. Complete statements about the characteristics of filler rods for braze welding. Circle the information that best completes each statement.

   a. Filler rods consist of copper alloys containing about (60 percent copper and 40 percent zinc) (60 percent copper and 40 percent brass), which:

      (1) Produce a high (tensile) (shear) strength.

      (2) Increase (ductility) (malleability).

   b. Filler rods contain small quantities of tin, iron, manganeses, and (silicon) (aluminum), which help to:

      (1) Deoxidize the (weld metal) (welding rod).

      (2) Decrease the tendency to (fume) (overheat).

      (3) Increase the free-flowing action of the (molten metal) (welding rod).

      (4) Increase the hardness of the deposited metal for greater (wear resistance) (adherence).

   c. Filler rods should be cleaned with (emery cloth) (a file) before use.

9. Complete statements about important factors in successful braze welding. Circle the numbers of the information that best completes the following statements.

   a. Successful braze welding really starts with:

      (1) Good equipment.

      (2) Careful planning.

      (3) Cleaning and properly preparing the joint.

   b. Proper precoating is achieved through the cleaning action of the flux and by:

      (1) Good torch and rod manipulation.

      (2) Maintaining proper metal temperature.

      (3) Selecting the proper rod.

c. When a weld is made in two or more passes, the result to inspect for is:

  (1) Complete fusion between layers of filler metal.

  (2) A flux-free weld.

  (3) Adherence with the base metal.

10. Select true statements about techniques used in preparing joints for braze welding. Place an "X" beside each true statement.

______a. Generally, prepare joints for braze welding the same as for fusion welding base metals of like thickness.

______b. When braze welding base metal no thicker than ⅛" to 3⁄16", you may use beveled edges.

______c. When braze welding metals thicker than 3⁄16", use square edges.

______d. In all cases, clean thoroughly every part of the base metal to be precoated until it is completely free of rust, scale, oil, and grease.

______e. Whenever possible, clean base metal at least ½" back from the edge of the joint.

11. Complete statements about techniques used to remove oxides in preparing joints for braze welding. Circle the information that best completes each of the following statements.

a. Remove oxides mechanically with a (torch) (wire brush or portable grinder) or chemically with a suitable (powder) (flux).

b. Sometimes, to achieve a thorough cleaning of the joint, you must use (machining) (both chemical and mechanical methods).

12. Complete statements about techniques used for braze welding steel and cast iron. Circle the numbers of the information that best completes each of the following statements.

a. A welding tip for braze welding steel and cast iron should be:

  (1) One size smaller than a tip selected for fusion welding a metal of equal thickness.
  (2) One size larger than a tip selected for fusion welding a metal of equal thickness.

Written Test

b. For braze welding, the torch should be adjusted to:

   (1) A neutral to slightly carburizing flame.
   (2) A neutral to slightly reducing flame.

c. Preheating for braze welding calls for moving the torch back and forth over a generous area of the base metal until it begins to:

   (1) Turn bright red.
   (2) Glow dull red.

d. In braze welding, after proper preheat, the end of the filler rod should be heated and:

   (1) Placed immediately on the joint.
   (2) Dipped in flux.

e. The temperature is just right for braze welding when:

   (1) The melted bronze flows smoothly over a large area of the base metal.
   (2) The bronze drops off in uniform quantities onto the base metal.

13. Match braze welding problems with their causes. Circle the number of the cause of each of the following problems.

a. When the molten bronze forms into drops, it means:

   (1) The base metal is too hot.
   (2) The base metal is not yet hot enough.

b. When the molten bronze tends to bubble and boil, it means:

   (1) The base metal is too hot.
   (2) The base metal is not yet hot enough.

14. Differentiate between the definitions of *surfacing* and *hardfacing*. Place a "B" beside the definition of bronze surfacing and an "H" beside the definition of hardfacing.

______a. Braze-welding technique used to rebuild or resurface worn parts

______b. Welding process used to deposit specialized alloys onto parts subject to extensive wear so that the parts become more resistant to abrasion, corrosion, impact, and high temperature

Written Test

15. Select true statements about the advantages of bronze surfacing. Place an "X" beside each true statement.

    ______a. When bronze is applied to steel or cast iron parts subject to sliding friction, the reconditioned parts sometimes give longer service than brand new parts.

    ______b. When large pistons have to be replaced, the cost of bronze surfacing is only slightly more than the cost of a new piston, and pistons rebuilt in this way will sometime outlast new pistons.

    ______c. Cast iron gears can be rebuilt faster at less cost with bronze welding than with oxyacetylene or arc welding.

16. Complete statements about limitations of bronze welding. Circle the information that best completes each of the following statements.

    a. Bronze surfacing should not be used on parts such as (superheated steam engine pistons) (high torque turbine blades) that will be subjected to temperatures above 500°F.

    b. Bronze surfacing should not be used on parts such as (piston rods) (valves) that will be subjected to alternating tensile and compressive stresses.

17. Differentiate between methods preparing new and cast iron surfaces for bronze surfacing. Place an "X" beside the statement that tells how to prepare cast iron surfaces for bronze surfacing.

    ______a. These surfaces should be machined or ground, or in some cases, just thoroughly cleaned before bronze is applied.

    ______b. These surfaces, should be ground or sand blasted because machining could leave graphite smears that make proper precoating difficult.

18. Select true statements about guidelines for bronze surfacing. Place an "X" beside each true statement.

    ______a. Remember that bronze surfacing is essentially a hardfacing process.

    ______b. When preheating a cast iron part, don't isolate the flame in one spot too long, but move the flame around to distribute heat evenly and avoid cracking the cast iron.

    ______c. When preheating steel, avoid excessive heat build-up in one area or the part could be permanently distorted.

Written Test

______d. Use a neutral or slightly carburizing flame and a good brazing flux.

______e. To avoid variances in quality, plan the application so that the job can be completed without interruption.

______f. Keep the layer of bronze just thick enough so that the lowest spots will still require some finish machining.

______g. Always allow the part to cool slowly to room temperature before machine finishing.

19. Select true statements about guidelines for hardfacing applications. Place an "X" beside each statement that is true.

______a. Hardfacing is usually confined to only that portion of a part that is subject to critical wear, not the entire part.

______b. Hardfacing is frequently used on surface areas, edges, or points that are subjected to contact or impact wear.

______c. Hardfacing is usually applied over a base metal selected for general strength and economy, but hardfacing alloys are selected for specific wearing conditions.

20. Match hardfacing alloys with their definitions. Place the reference number of the alloys in the blank beside the proper definition.

______a. Materials that are alloyed up to 12 percent with chromium, molybdenum, or manganese

______b. Materials with 12 to 50 percent alloy content of chromium and sometimes nickel and cobalt

______c. Materials that contain a small amount of iron, usually cobalt-chromium-tungsten alloys that are expensive but have high resistance to corrosion and oxidation

______d. Materials that combine the qualities of hardness and brittleness required to make manufacturing tools

1. Cobalt-base and nickel-base alloys
2. Low-alloy, iron-base alloys
3. Tungsten-carbide alloys
4. High-alloy, iron-base alloys

Written Test

21. Complete statements about hardfacing powders and their characteristics. Circle the information that best completes each of the following statements.

    a. Powders are used primarily on (thick) (thin) base metals that cannot tolerate the heat of conventional arc or oxyacetylene hardfacing.

    b. Powders produce deposits so (smooth) (strong) that some parts can be returned to service with no additional machining.

    c. Powders may be sprayed on with a spray gun or a hand-held torch assembly, and torch grade powders usually have an improved (wetting) (cleaning) action.

    d. Powders range from nickel-base alloys for (cast iron) (general) use to cobalt-based alloys where nickel cannot be used.

    e. Powders are normally fused onto the base metal with a (reducing) (carburizing) flame after preheating to 600°-800°F.

22. Complete statements about the advantages of hardfacing with an oxyacetylene torch. Circle the number of the information that best completes each of the following statements.

    a. Since more pounds per hour can be deposited with arc welding, it would seem that hardfacing with an oxyacetylene flame would not have an advantage, but yet:

        (1) The oxyacetylene flame is faster.
        (2) The oxyacetylene flame does not require learning arc welding skills.
        (3) The oxyacetylene flame holds dilution of the hardfacing alloys to a minimum.

    b. One special advantage that oxyacetylene has over arc hardfacing is that:

        (1) Oxyacetylene is very portable.
        (2) Oxyacetylene can deposit alloys in minimal thicknesses to save expensive materials, and arc welding processes that can do this are very expensive.
        (3) Oxyacetylene is by far the least expensive process.

23. Complete statements about guidelines for preparing surfaces for hardfacing. Circle the information that best completes each of the following statements.

    a. Thoroughy clean surfaces so that they are free of oxides, dirt, oil, or (any foreign substance) (slag).

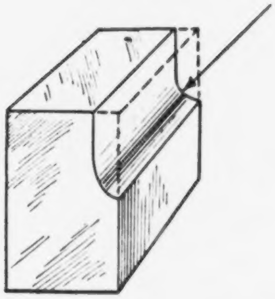
    b. Because hardfacing applications are limited to (only edges) (specific sections of a part), you must almost always grind or machine a surface.

    c. (Grind) (Round off) all sharp corners.

Written Test

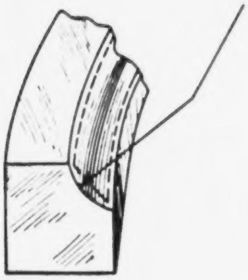
24. Identify requirements for machining surfaces to be hardfaced. Circle the number of the information that best describes the machining required in each of the following illustrations.

a.



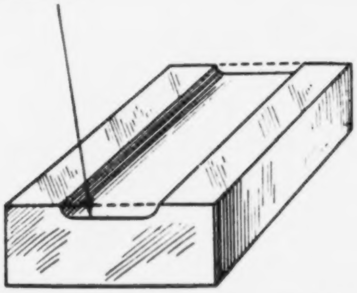
(1) An edge or corner joint that will to be subjected to shock should be prepared as illustrated.
(2) A corner that will be subjected to heavy impact should be prepared as illustrated.

b.



(1) An edge or corner that will be subjected to heavy impact should be prepared as illustrated.
(2) An edge or a corner that will not be subjected to heavy impact should be prepared as illustrated.

c.



(1) Longitudinal areas such as rolling guides should be prepared as illustrated.
(2) A stress area subject to abrasive friction should be prepared as illustrated.

Written Test

25. Select true statements about preheating and cooling requirements for hardfacing. Place an "X" beside each statement that is true.

_______a. Some degree of preheating is required in almost all hardfacing applications.

_______b. Larger parts must be fully preheated either with a torch or in a preheating furnace.

_______c. Parts should not be overheated or oxides may form on the surface.

_______d. Preheating should be applied evenly to avoid surface cracking in cooling.

_______e. After hardfacing the part should be cooled rapidly, and this is an extremely important factor in the process.

26. Complete statements about techniques used for oxyacetylene hardfacing. Circle the number of the information that best completes each of the following statements.

a. After preheating, the torch should be held about ⅛" from the surface, and then the torch should be held still until:

(1) The surface turns dull red.
(2) The surface turns bright red.
(3) The surface sweats and gives a glazed appearance.

b. When hardfacing starts, as the end of the rod melts and forms a puddle on the surface, if the puddle does not spread out uniformly on the surface, it means:

(1) You picked the wrong welding rod.
(2) The metal was improperly cleaned.
(3) The metal needs more preheating.

c. If the first drops spread uniformly, the rod should then be withdrawn from the flame, and then:

(1) Move the torch slightly left or right and reinsert the rod.
(2) Direct part of the flame on the puddle and part on the surrounding base metal to spread the alloy farther.
(3) Put the rod slowly back into the flame.

Written Test

27. Select true statements about techniques for making a second pass when oxyacetylene hardfacing. Place an "X" beside each statement that is true.

    ______a. After the first pass is completed, the surface will not sweat, so a second pass requires special attention.

    ______b. Move the puddle by rod action, not with flame pressure.

    ______c. Work toward the hand holding the rod, using the forehand technique.

    ______d. When oxides or particles of dirt appear on the surface, try to float them to the surface with the flame, and use the rod to remove particles only when flame action doesn't get the job done.

    ______e. Cool the part rapidly after the final pass is complete.

    ______f. Finish grinding or machining the part to specifications.

28. Complete statements about safety precautions used for hardfacing. Circle the number of the information that best completes each of the following statements.

    a. Some fluxes that contain fluorine compounds can become toxic when vaporized, and that's why:

        (1) You should always wear a respirator.
        (2) The hardfacing workplace should be well ventilated.
        (3) Fluxes with fluorine compounds should never be used.

    b. Some steels that have a white coating and other steels that turn yellow-gold when heated pose the possibility that dangerous fumes might be generated with the vaporization of:

        (1) Magnesium in the steel.
        (2) Nickel alloys in the steel.
        (3) Cadmium in the steel.

    c. The basic rule for using a vapor degreaser for cleaning metal to be hardfaced is to:

        (1) Always apply the degreaser with a clean rag.
        (2) Make sure that the cleaner has dried and that all fumes have evaporated.
        (3) Dilute the degreaser with a common household detergent.

***Permission to duplicate this test is granted.**

Oxyacetylene Braze Welding and Surfacing
Unit 3

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Job Sheet 1—Weld a Stringer Bead with a Bronze Rod on Steel Plate Rating _____

Comments: ____

____

Job Sheet 2—Braze Weld a Square Groove Butt Joint in the Flat Position Rating _____

Comments: ____

____

Job Sheet 3—Braze Weld a Lap Joint in the Horizontal Position Rating _____

Comments: ____

____

Job Sheet 4—Repair a Worn Tool with Hardfacing Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

Metals Preheating Chart

METAL GROUP	METAL DESIGNATION	C.	RECOMMENDED PREHEAT
PLAIN CARBON STEEL	Plain Carbon Steel	Below .20	Up to 200°F
	Plain Carbon Steel	.20 - .30	200°F - 300°F
	Plain Carbon Steel	.30 - .45	300°F - 500°F
	Plain Carbon Steel	.45 - .80	500°F - 800°F
CARBON MOLY STEELS	Carbon Moly Steel	.10 - .20	300°F - 500°F
	Carbon Moly Steel	.20 - .30	400°F - 600°F
	Carbon Moly Steel	.30 - .35	500°F - 800°F
MANGANESE STEELS	Silicon Structural Steel	.35	300°F - 500°F
	Medium Manganese Steel	.20 - .25	300°F - 500°F
	SAE T 1330 Steel	.30	400°F - 600°F
	SAE T 1340 Steel	.40	500°F - 800°F
	SAE T 1350 Steel	.50	600°F - 900°F
	12% Manganese Steel	1.25	Usually Not Required
HIGH TENSILE STEELS	Manganese Moly Steel	.20	300°F - 500°F
	Manten Steel	.30 Max.	400°F - 600°F
	Armco High Tensile Steel	.12 Max.	Up to 200°F
	Double Strength #1 Steel	.12 Max.	300°F - 600°F
	Double Strength #1A Steel	.30 Max.	400°F - 700°F
	Cr-Cu-Ni Steel	.12 Max.	200°F - 400°F
	Cr-Mn Steel	.40	400°F - 600°F
	Hi-Steel	.12 Max.	200°F - 500°F
NICKEL STEELS	SAE 2015 Steel	.10 - .20	Up to 300°F
	SAE 2115 Steel	.10 - .20	200°F - 300°F
	2½% Nickel Steel	.10 - .20	200°F - 400°F
	SAE 2315 Steel	.15	200°F - 500°F
	SAE 2320 Steel	.20	200°F - 500°F
	SAE 2330 Steel	.30	300°F - 600°F
	SAE 2340 Steel	.40	400°F - 700°F

Oxyacetylene Braze Welding and Surfacing
Unit 3

Information Sheet

1. **Terms and definitions**

   a. **Carburizing flame** — A flame with more acetylene than a neutral flame

   b. **Flux** — A material used to hinder or prevent the formation of oxide and other undesirable substances in molten metal and on solid metal surface, and to dissolve or otherwise facilitate the removal of such substances

   c. **Hardfacing** — A surfacing variation in which surfacing material is deposited to reduce wear

   d. **Machining** — Mechanically grinding or milling surfaces, edges, and corners to precise dimensions of a workpiece to be welded; finishing a workpiece after welding

   e. **Oxidation** — The chemical reaction of a metal with oxygen in the air in a process that promotes contamination of metal surfaces and eventually leads to rust

   f. **Oxidizing flame** — A flame with more oxygen than a neutral flame

   g. **Precoating** — Coating the base metal in a joint by dipping, electroplating, or other means prior to soldering or brazing

   Note: Precoating is also called *tinning.*

2. **Definitions of *fusion welding* and *braze welding***

   a. In fusion welding, the filler rod has a melting point approximately the same as the melting point of the base metal, and both the filler metal and the base metal are melted and fused together.

   b. In braze welding, the filler rod has a melting point below the melting point of the base metal, the base metal is never melted, and the weld is formed as a result of gravity pull resulting from weld design.

Information Sheet

3. Definitions of *brazing* and *braze welding*

a. In brazing, the filler metal must have a melting point above 840°F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction.

b. In braze welding, the filler metal must have a melting point above 840°F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction.

4. Advantages of braze welding

a. Braze welding is faster than fusion welding because the heat input required is less.

b. Braze welding saves time and reduces fuel gas consumption.

c. Braze welding minimizes preheating requirements.

d. In braze welding, the reduction of heat input has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools.

e. Because of a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal.

f. Braze welding can be used to join dissimilar metals that cannot be fusion welded.

Example: Copper to brass

5. Limitations of braze welding

a. In braze welding, the weld color cannot match the base metal.

b. Because there is no filler rods for special applications, braze welding cannot be used on metals and joints where high stress is a factor.

c. A braze weld will lose its strength at temperatures above 500°F.

d. A braze weld may have corrosion-resistant properties different from those of the base metal.

e. The strength of a braze weld is limited to the strength of the filler metal.

Information Sheet

6. **Statements about precoating in braze welding**

   a. Braze welding is based on the principle that brass and bronze when raised to the proper temperature will melt and form a smooth precoating film on the surface of a properly prepared and heated joint.

   b. Precoating cannot be properly accomplished unless the joint has been thoroughly cleaned and properly prepared.

   c. Good precoating requires a neutral to slightly reducing flame.

   d. Precoating requires a good brazing flux.

   e. Improper precoating action is almost always caused by overheating the base metal.

7. **Purposes of flux**

   a. Flux chemically cleans the base metal.

   b. Flux prevents oxidation of the filler metal.

   c. Flux floats and removes the oxides already present.

   d. Flux increases the flow of the filler metal.

   e. Flux increases the ability of the filler metal to adhere to the base metal.

   f. Flux brings the filler metal into immediate contact with the metals being joined.

   g. Flux permits the filler metal to penetrate the pores of the base metal.

8. **Characteristics of filler rods for braze welding**

   a. Filler rods consist of copper alloys containing about 60 percent copper and 40 percent zinc, which:

      (1) Produce a high tensile strength.

      (2) Increase ductility.

   b. Filler rods contain small quantities of tin, iron, manganeses, and silicon, which help to:

      (1) Deoxidize the weld metal.

      (2) Decrease the tendency to fume.

      (3) Increase the free-flowing action of the molten metal.

      (4) Increase the hardness of the deposited metal for greater wear resistance.

   c. Filler rods should be cleaned with emery cloth before use.

Information Sheet

9. **Important factors in successful braze welding**

   a. Cleaning and properly preparing the joint is a must.

   b. Proper precoating of the joint is achieved through the cleaning action of the flux and by maintaining proper metal temperature.

   c. Complete fusion between layers of filler metal is essential when the weld is made in two or more passes.

10. **Techniques used in preparing joints for braze welding**

    a. Generally, prepare joints for braze welding as for fusion welding base metals of like thickness.

    b. When braze welding base metal no thicker than ⅛" to 3/16", you may use square edges.

    c. When braze welding metals thicker than 3/16", use beveled edges.

    d. In all cases, thoroughly clean every part of the base metal to be precoated until it is completely free of oxides, oil, and grease.

    e. Whenever possible, clean base metal at least ½" back from the edge of the joint.

11. **Techniques used to remove oxides in preparing joints for braze welding**

    a. Remove oxides mechanically with a wire brush or portable grinder or chemically with a suitable flux.

    b. Sometimes to achieve a thorough cleaning of the joint, you must use both chemical and mechanical methods.

12. **Techniques for braze welding steel and cast iron**

    a. Select a welding tip at least one size smaller than a tip selected for fusion welding a metal of equal thickness.

    b. Adjust torch to a neutral or slightly reducing flame.

    c. For preheating, move the flame back and forth over a generous area of the base metal until it begins to glow dull red.

Information Sheet

d. As the base metal starts to glow dull red, heat the end of the filler rod and dip it in flux until it is well coated.

Note: To flux longer rods, spread the flux out along the inside corner of a piece of angel iron so the entire length of the rod can be dipped in the flux at one time or use flux-coated rods to eliminate the need for additional flux.

e. As the base metal becomes dull red, move the rod into the flame until it comes in contact with and melts off onto the base metal.

f. When the melted bronze flows smoothly onto the surface of the base metal and flows evenly over a large area, the temperature is just right.

13. **Braze welding problems and their causes**

a. Molten bronze forms into drops — Base metal is not yet hot enough

b. Molten bronze tends to bubble and boil — Base metal is too hot

14. **Definitions of *bronze surfacing* and *hardfacing***

a. Bronze surfacing — Braze-welding technique used to rebuild or resurface worn parts

b. Hardfacing — Welding process used to deposit specialized alloys onto parts subject to extensive wear so that the parts become more resistant to abrasion, corrosion, impact, and high temperature

15. **Advantages of bronze surfacing**

a. When bronze is applied to steel or cast iron parts subject to sliding friction, the reconditioned parts sometimes give longer service than brand new parts.

Examples: Pistons, rotary valves, and large gears are typical of parts subjected to wear from sliding friction

b. When large pistons have to be replaced, the cost of bronze surfacing is much less than the cost of a new piston, and pistons rebuilt in this way will sometimes outlast new pistons.

c. Cast iron gears can be rebuilt faster at less cost with bronze welding than with oxyacetylene or arc welding.

Information Sheet

16. Limitations of bronze welding

a. Bronze surfacing should not be used on parts such as superheated steam engine pistons that will be subjected to temperatures above 500°F.

b. Bronze surfacing should not be used on parts such as piston rods that will be subjected to alternating tensile and compressive stresses.

17. Methods of preparing new and cast iron surfaces for bronze surfacing

a. New or almost new surfaces should be machined or ground, or in some cases, just thoroughly cleaned before bronze is applied.

b. Cast iron surfaces should be ground or sand blasted because machining could leave graphite smears that make proper precoating difficult.

18. Guidelines for bronze surfacing

a. Remember that bronze surfacing is essentially a braze welding process.

b. When preheating a cast iron part, don't isolate the flame in one spot too long, but move the flame around to distribute heat evenly and avoid cracking the cast iron.

c. When preheating steel, avoid excessive heat build-up in one area or the part could be permanently distorted.

d. Use a neutral or slightly reducing flame and a good brazing flux.

e. To avoid variances in quality, plan the application so that the job can be completed without interruption.

f. Keep the layer of bronze just thick enough so that the lowest spots will still require some finish machining.

g. Always allow the part to cool slowly to room temperature before machine finishing.

19. Guidelines for hardfacing applications

a. Hardfacing is usually confined to only that portion of a part that is subject to critical wear, not the entire part.

b. Hardfacing is frequently used on surface areas, edges, or points that are subjected to contact or impact wear.

Information Sheet

c. Hardfacing is usually applied over a base metal selected for general strength and economy, but hardfacing alloys are selected for specific wearing conditions.

20. Definitions of types of hardfacing alloys

a. Low-alloy, iron-base alloys — Materials that are alloyed up to 12 percent with chromium, molybdenum, or manganese

b. High-alloy, iron-base alloys — Materials with 12 to 50 percent alloy content of chromium and sometimes nickel and cobalt

c. Cobalt-base and nickel-base alloys — Materials that contain a small amount of iron, usually cobalt-chromium-tungsten alloys that are expensive but have high resistance to corrosion and oxidation

d. Tungsten-carbide alloys — Materials that combine the qualitites of hardness and brittleness required to make manufacturing tools

21. Hardfacing powders and their characteristics

a. Powders are used primarily on thin base metals that cannot tolerate the heat of conventional arc or oxyacetylene hardfacing.

b. Powders produce deposits so smooth that some parts can be returned to service with no additional machining.

c. Powders may be sprayed on with a spray gun or a hand-held torch assembly, and torch grade powders usually have an improved wetting action.

d. Powders range from nickel-base alloys for general use to cobalt-based alloys where nickel cannot be used.

e. Powders are normally fused onto the base metal with a reducing flame after preheating to 600°-800°F.

22. Advantages of hardfacing with an oxyacetylene torch

a. An oxyacetylene flame can be used with all hardfacing alloys.

b. More pounds per hour can be deposited when hardfacing with arc welding, but dilution of the hardfacing alloys is held to a minimum with an oxyacetylene flame.

Information Sheet

c. With an oxyacetylene flame, alloys can be deposited in minimal thicknesses to save expensive materials, and arc processes that can do this are very expensive.

d. An oxyacetylene unit can always be taken to the work, but with other processes the work has to be taken to the welding equipment.

23. Guidelines for preparing surfaces for hardfacing

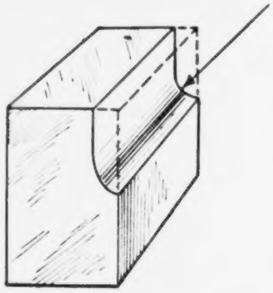
a. Thoroughly clean surfaces so that they are free of oxides, dirt, oil, or any foreign substance.

b. Because hardfacing applications are limited to specific sections of a part, you must almost always grind or machine a surface.

c. Round off all sharp corners.

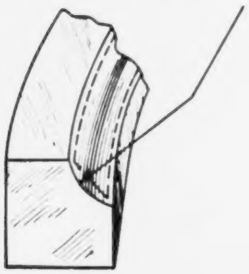
24. Requirements for machining surfaces to be hardfaced

a. When a hardfaced edge or corner will be subjected to shock, such as on a punch or shear blade, the steel should be machined as indicated in the following illustration.



Courtesy Union Carbide Corporation, Linde Division

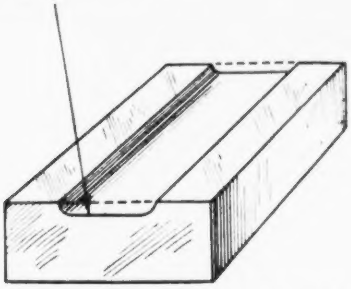
b. When a hardfaced angle, edge, or corner will not be subjected to heavy impact, the steel should be machined as indicated in the following illustration.



Courtesy Union Carbide Corporation, Linde Division

Information Sheet

c. When hardfacing is to be applied to a longitudinal area such as a rolling guide, the steel should be machined with a radii equal to the depth of the groove, as indicated in the following illustration.



Courtesy Union Carbide Corporation, Linde Division

25. Preheating and cooling requirements for hardfacing

a. Some degree of preheating is required in almost all hardfacing applications.

b. Larger parts must be fully preheated either with a torch or in a preheating furnace.

c. Parts should not be overheated or oxides may form on the surface.

d. Preheating should be applied evenly to avoid surface cracking in cooling.

e. After hardfacing, the part should be cooled SLOWLY, and this is an extremely important factor in the process.

Information Sheet

METAL GROUP	METAL DESIGNATION	C.	RECOMMENDED PREHEAT
PLAIN CARBON STEEL	Plain Carbon Steel	Below .20	Up to 200°F
	Plain Carbon Steel	.20 - .30	200°F - 300°F
	Plain Carbon Steel	.30 - .45	300°F - 500°F
	Plain Carbon Steel	.45 - .80	500°F - 800°F
CARBON MOLY STEELS	Carbon Moly Steel	.10 - .20	300°F - 500°F
	Carbon Moly Steel	.20 - .30	400°F - 600°F
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	SAE T 1340 Steel	.40	500°F - 800°F
	SAE T 1350 Steel	.50	600°F - 900°F
	12% Manganese Steel	1.25	Usually Not Required
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	2½% Nickel Steel	.10 - .20	200°F - 400°F
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	SAE 2320 Steel	.20	200°F - 500°F
	SAE 2330 Steel	.30	300°F - 600°F
	SAE 2340 Steel	.40	400°F - 700°F

26. Techniques used for oxyacetylene hardfacing

a. When working on steel, use a neutral or slightly carburizing flame.

b. After preheating, direct the flame onto the surface of the metal at an angle from 30° to 60° with the tip of the inner cone about ⅛" from the surface.

c. Hold the torch still until the surface sweats and gives a glazed appearance.

Information Sheet

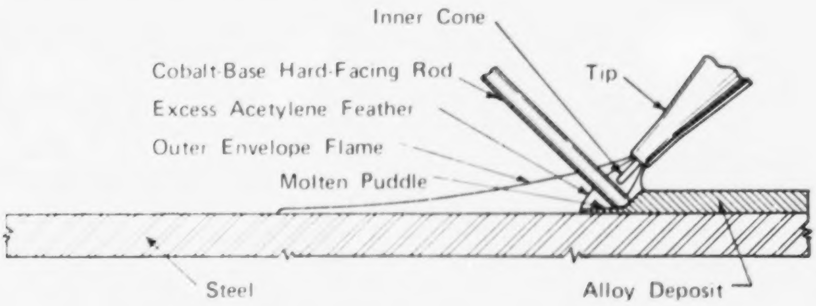
d. Withdraw the flame enough so that the end of the rod can be brought between the inner cone and the hot base metal so that the tip of the cone just about touches the rod and the rod touches the sweating surface.

e. As the end of the rod melts and forms a puddle on the surface, make sure the first drop or two spreads out uniformly on the surface, and if it doesn't, the base metal needs more preheating.

f. If the first drops spread uniformly, withdraw the rod from the flame and spread the alloy farther by directing part of the flame on the puddle and part onto surrounding base metal.

g. As the puddle spreads, put the rod into the flame again with its end touching the puddle, and melt more alloy into the puddle.

h. Alternately move the puddle with the flame and reinsert the rod to deposit more alloy until the surface is covered.



Courtesy Union Carbide Corporation, Linde Division

27. Techniques for making a second pass when oxyacetylene hardfacing

a. After the first pass is completed, the surface will not sweat, so a second pass requires special attention.

b. Move the puddle by flame pressure, not with rod action.

c. Work toward the hand holding the rod, using the forehand technique.

d. When oxides or particles of dirt appear on the surface, try to float them to the surface with the flame, and use the rod to remove particles only when flame action doesn't get the job done.

Information Sheet

e. Cool the part slowly after the final pass is complete.

Note: Controlled cooling is sometimes accomplished by wrapping or burying the part in dry lime, dry sand, or wood ashes; in some shops, furnaces with controlled cooling rates are used, but asbestos coverings should not be used.

f. Finish grinding or machining the part to specifications.

28. Safety precautions used for hardfacing

a. Observe all safety rules for normal setup and operation of oxyacetylene equipment.

b. Keep work area free of flammable materials and know the location of the nearest fire extinguisher.

c. Make sure the area is well ventilated because some fluxes used in hard surfacing contain fluorine compounds that become toxic when carbonized.

d. Take special precautions with steels that have white colored coatings or that turn yellow-gold when torch heated; this means cadmium is present in the protective coating and cadmium can generate dangerous fumes as it vaporizes.

e. Before hardfacing parts that have been cleaned with a vapor-degreaser, make sure the cleaner has dried and that all fumes have evaporated before.

Oxyacetylene Braze Welding and Surfacing
Unit 3

Job Sheet 1—Weld a Stringer Bead with a Bronze Rod on Steel Plate

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Workpiece preparation	______
Equipment setup and safety	______
Flame adjustment	______
Proper use of flux	______
Filler rod and torch manipulation	______
Quality of final bead	______

A. Tools and materials

Oxyacetylene welding unit with brazing tip
Welding goggles, safety glasses, and face shield
Welding gloves
Portable grinder
Vise
Pliers
Steel plate as selected by instructor
Bronze filler rod as selected by instructor
Flux of flux-coated filler rod as selected by instructor
Firebrick worktable
Chipping hammer and wire brush

B. Procedure

☐ 1. Check work area to assure that it is free of flammable materials and properly ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place selected metal in vise and grind surface to remove oxides.

> **Caution: Always wear safety glasses and a face shield when grinding.**

Job Sheet 1

☐ 3. Position metal flat on the firebrick worktable.

☐ 4. Select recommended brazing tip and put it on the torch finger tight.

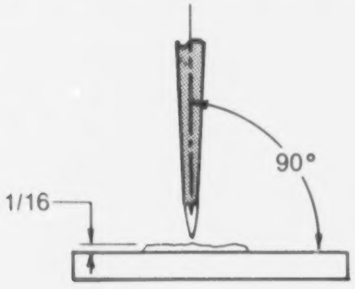
☐ 5. Set up equipment and light torch according to safety procedures previously outlined.

☐ 6. Adjust to a neutral or slightly reducing flame.

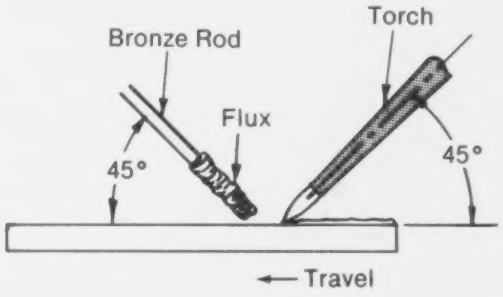
☐ 7. Place rod so that half of it extends over worktable; hold the free end, then melt the rod in half to make it easier to handle and safer to work with.

☐ 8. Heat rod slightly and dip in flux, if required.

☐ 9. Hold the torch at approximately a 90° work angle and a 45° travel angle, and move it down until flame is about ⅛″ from the surface of the metal.



Front View



Side View

☐ 10. Heat an area of the base metal about ½″ in diameter with a slightly circular torch motion until the metal is dull red.

☐ 11. Immediately after the metal turns dull red, insert the end of the rod into the area where the cone of the flame meets the plate.

☐ 12. Allow a drop of molten bronze to form the beginning of the bead.

☐ 13. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to drop on the plate.

☐ 14. Check the rod frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the metal as you quickly dip the rod in the flux.

Job Sheet 1

☐ 15. Move flame back onto the metal and continue the procedure until the bead is completed.

☐ 16. Stop just as you reach the end of the metal so molten bronze will not drip off the workpiece.

☐ 17. Shut torch off.

☐ 18. Inspect bead for consistent width, proper height, and uniform flow and adhesion to the base metal.

Note: When too much flux gets on the bead, it may require cleaning before inspection.

☐ 19. Repeat the previous procedure until several parallel beads have been made across the sheet metal, and be sure to stop and clean and inspect as each bead is completed.

☐ 20. Have your instructor check your work.

☐ 21. Clean up area and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Braze Welding and Surfacing
Unit 3

Job Sheet 2—Braze Weld a Square Groove Butt Joint in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Workpiece preparation	______
Equipment setup and safety	______
Flame adjustment	______
Proper use of flux	______
Filler rod and torch manipulation	______
Quality of final bead	______

A Tools and materials

Oxyacetylene welding unit with brazing tip
Welding goggles, safety glasses, and face shield
Welding gloves
Portable grinder
Vise
Pliers
Steel plate as selected by instructor
Bronze rod as selected by instructor
Flux of flux-coated filler rod
Firebrick work table
Chipping hammer and wire brush

B. Procedure

☐ 1. Check work area to assure that it is free of flammable materials and properly ventilated; note the location of the nearest fire extinguisher.

☐ 2. Place selected metal in vise and grind surface to remove oxides.

Caution: Always wear safety glasses and a face shield when grinding.

Job Sheet 2

☐ 3. Position the workpieces flat on the firebrick and align them about ¹⁄₁₆″ apart for a butt joint.

Note: Do not lay the pieces of metal flat on the firebrick; place other pieces of metal or firebricks under them so there will be a space between the workpieces and the worktable.

☐ 4. Select recommended brazing tip and put it on the torch finger tight.

☐ 5. Set up equipment and light torch according to safety procedures previously outlined.

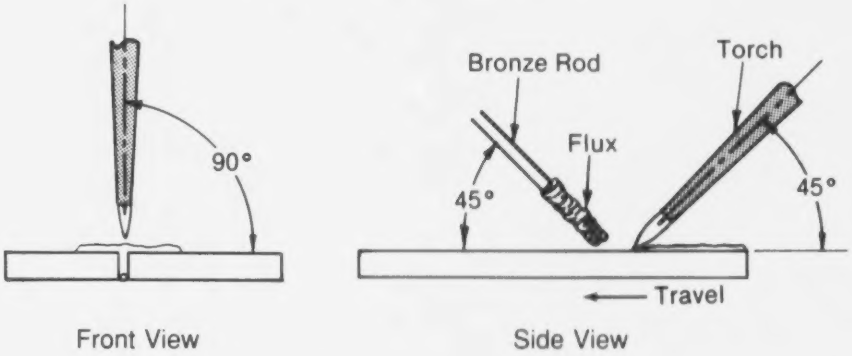
☐ 6. Adjust to a neutral or slightly reducing flame.

☐ 7. Place rod so that half of it extends over worktable; hold the free end, then melt the rod in half to make it easier to handle and safer to work with.

☐ 8. Heat rod slightly and dip in flux, if required.

☐ 9. Tack each end of the joint.

☐ 10. Hold the torch at approximately a 90° work angle and a 45° travel angle and move down until the flame is about ⅛″ from the surface of the metal.



☐ 11. Heat about ⅛″ of each edge of the joint with a slight circular motion of the torch until the edges are dull red.

☐ 12. Position the flame in the center of the joint as you insert the rod into the cone of the flame.

☐ 13. Allow a drop of molten bronze to fill the joint.

Job Sheet 2

☐ 14. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to enter the joint.

☐ 15. Check the rod frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the joint as you quickly dip the rod in the flux.

☐ 16. Move flame back into the center of joint and continue the procedure until the joint is completely brazed.

☐ 17. Stop just as you cover the tack weld so molten bronze will not drip off the end of the joint.

☐ 18. Shut torch off.

☐ 19. Inspect face of bead for consistent width, proper height, and uniform flow and adhesion to the base metal.

☐ 20. Inspect reverse side of joint for penetration.

Caution: Never pick up a piece of hot metal even when you're wearing leather gloves; always handle hot metal with a pair of pliers.

☐ 21. Have your instructor check your work.

☐ 22. Clean up area and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's comments: ____

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Oxyacetylene Braze Welding and Surfacing
Unit 3

Job Sheet 3—Braze Weld a Lap Joint in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Workpiece preparation	______
Equipment setup and safety	______
Flame adjustment	______
Proper use of flux	______
Filler rod and torch manipulation	______
Quality of final bead	______

A. Tools and materials

Oxyacetylene welding unit with brazing tip
Welding goggles, safety glasses, and face shield
Welding gloves
Portable grinder
Vise
Pliers
Steel plate as selected by instructor
Bronze rod as selected by instructor
Flux of flux-coated filler rod
Firebrick worktable
Chipping hammer and wire brush

B. Procedure

☐ 1. Check work area to assure that it is free of flammable materials and properly ventilated; note the location of the nearest fire extinguisher.

☐ 2. Place selected metal in vise and grind surface to remove oxides.

> **Caution: Always wear safety glasses and a face shield when grinding.**

Job Sheet 3

☐ 3. Position workpieces on firebrick and align them to make a lap joint.

☐ 4. Select recommended brazing tip and put it on the torch finger tight.

☐ 5. Set up equipment and light torch according to safety procedures previously outlined.

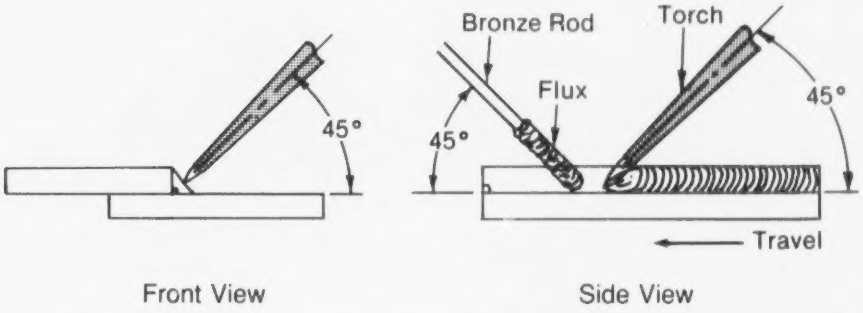
☐ 6. Adjust to a neutral or slightly reducing flame.

☐ 7. Place rod so that half of it extends over worktable; hold the free end, then melt the rod in half to make it easier to handle and safer to work with.

☐ 8. Heat rod slightly and dip in flux, if required.

☐ 9. Tack both corners of each side of the joint.

☐ 10. Hold the torch at approximately a 45° work angle and a 45° travel angle and move down until the flame is about ⅛" from the surface of the metal at the very corner of the joint.



☐ 11. Concentrate heat on the edge of the bottom plate first, then with a slightly circular motion, move the flame up and heat the top plate until both plates are dull red.

☐ 12. Position the flame in the center of the joint, then insert the rod into the cone of the flame.

☐ 13. Allow a drop of molten bronze to fill the joint.

☐ 14. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to enter the joint.

Job Sheet 3

☐ 15. Check the rod frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the joint as you quickly dip the rod in the flux.

☐ 16. Move flame back into the center of joint and continue the procedure until the joint is completely brazed.

☐ 17. Stop just as you cover the tack weld so molten bronze will not drip off the end of the joint.

☐ 18. Shut torch off.

☐ 19. Inspect bead for proper leg lengths, correct width and height, and uniform flow and adhesion to the base metal.

☐ 20. Turn metal over with the pliers and clean oxidation from other side.

☐ 21. Relight torch, adjust to a neutral or slightly reducing flame, and repeat the procedure on the other side of the joint.

☐ 22. Shut off torch.

☐ 23. Clean and inspect.

☐ 24. Have your instructor check your work.

☐ 25. Clean up area and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's comments: ______________________________

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Oxyacetylene Braze Welding and Surfacing
Unit 3

Job Sheet 4—Repair a Worn Tool with Hardfacing

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Workpiece preparation	______
Equipment setup and safety	______
Flame adjustment	______
Proper use of flux	______
Filler rod and torch manipulation	______
Quality of final bead	______

A. Tools and materials

- Oxyacetylene welding unit with brazing tip
- Welding goggles, safety glasses, and face shield
- Welding gloves
- Portable grinder
- Vise
- Pliers
- Worn plow share or other worn equipment as selected by instructor
- Hardfacing rod as selected by instructor
- Flux as required
- Firebrick worktable
- Wire brush

B. Procedure

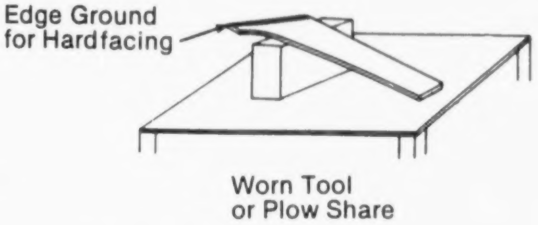
☐ 1. Check work area to assure that it is free of flammable materials and properly ventilated; note the location of the nearest fire extinguisher.

☐ 2. Secure the worn tool in a vise and grind approximately 1″ along the edge until the metal is bright.

Caution: Always wear safety glasses and a face shield when grinding.

Job Sheet 4

☐ 3. Place the tool with one end over a firebrick on the worktable so that the tool is inclined 20° to 30°.


Edge Ground
for Hardfacing
Worn Tool
or Plow Share

Courtesy Lincoln Electric Company

☐ 4. Select a recommended hardfacing tip and put it on the torch finger tight.

☐ 5. Set up equipment and light torch according to safety procedures previously outlined.

☐ 6. Adjust to a neutral or slightly reducing flame.

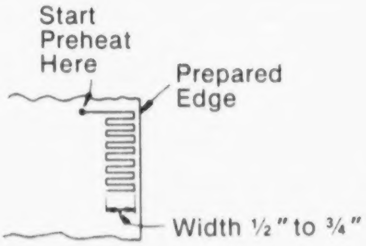
☐ 7. Preheat the total length of the edge to be hardfaced.

☐ 8. Adjust to a carburizing flame.

☐ 9. Move the flame down until it is about ⅛" above the surface of the workpiece.

☐ 10. Hold the flame still until the edge surface of the tool begins to sweat and displays a glazed appearance.

☐ 11. Withdraw the flame enough so that the end of the rod can be brought between the inner cone and the hot base metal so that the tip of the cone just about touches the rod and the rod touches the sweating surface.


Start
Preheat
Here
Prepared
Edge
Width ½" to ¾"

Job Sheet 4

☐ 12. Weave the torch slightly and allow a drop or two of molten alloy to drop onto the metal surface; make sure the molten alloy spreads out evenly over the area to be hardfaced.

Note: If the molten alloy does not flow easily and spread out uniformly, it usually indicates the base metal needs more preheating.

☐ 13. Withdraw rod from the flame, and spread the alloy further by directing part of the flame onto the puddle and part of the flame onto the surrounding base metal.

☐ 14. Put the rod into the flame again with its end touching the forward side of the puddle, and melt more alloy into the puddle.

☐ 15. Move the puddle with flame motion and alternately reinsert the rod to deposit more alloy until the surface is covered.

☐ 16. Shut torch off.

☐ 17. Inspect hardfacing to make sure there is good adherence between the alloy and the base metal.

☐ 18. Have your instructor check your work.

☐ 19. Clean up area and check in tools and materials.

Note: Your instructor may instruct you to repeat this job sheet using another selected worn tool because the procedure can be readily adapted to hardface plow moldboards, landside plates, grain discs, cultivator sweeps, chisels, and spikes and other types of running or cutting equipment.

Evaluator's comments: ______________________________

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